SAE Journal

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OCTOBER 1958

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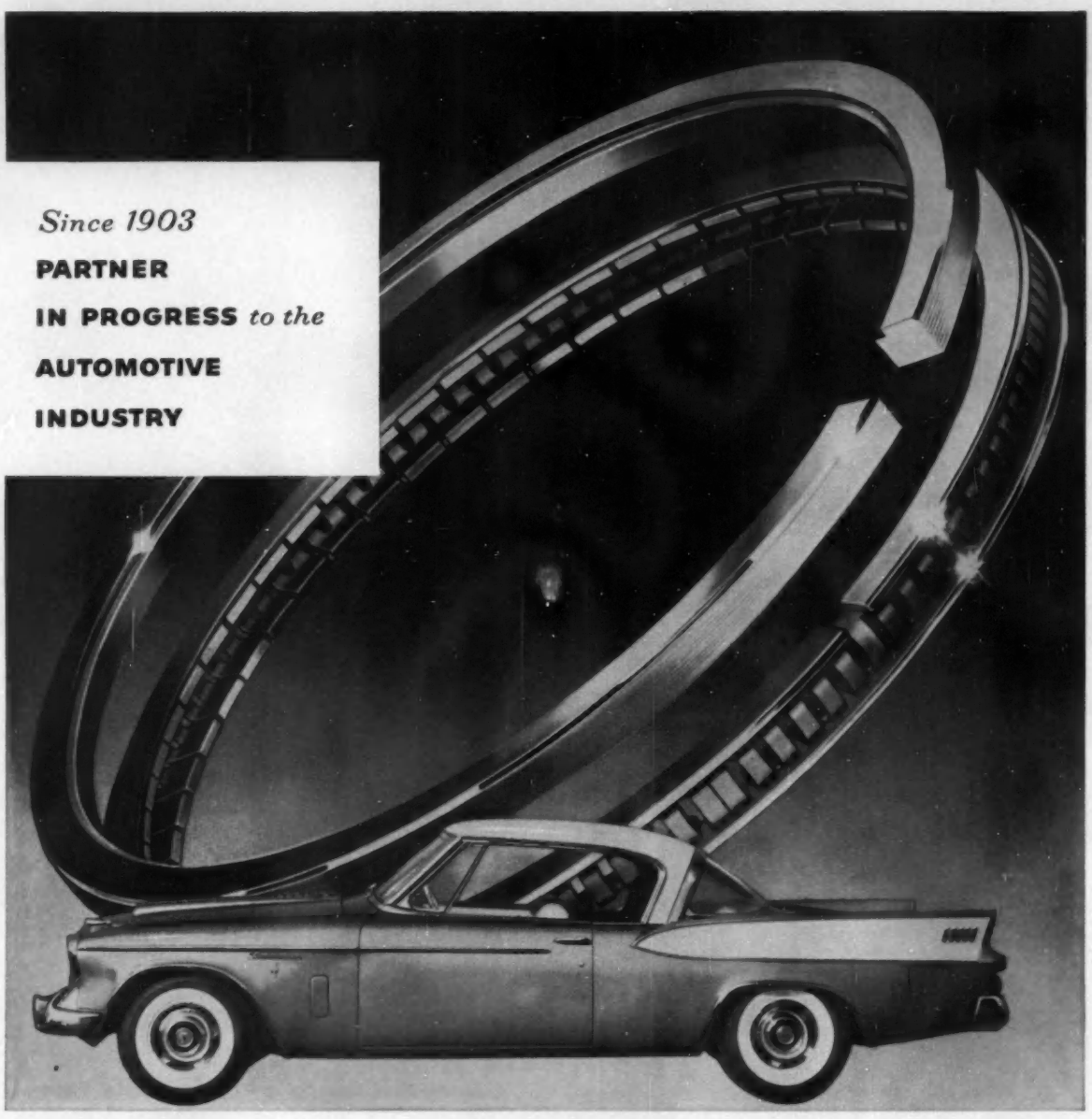

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Existing refinery and modern car data give a most-miles-per-dollar curve which peaks at 97 octane. Continued developments in petroleum and automobile industries are needed to raise substantially the optimum octane number. (Paper No. 74B) — **F. W. Kavanagh, J. R. MacGregor, R. L. Pohl, and M. B. Lawler**

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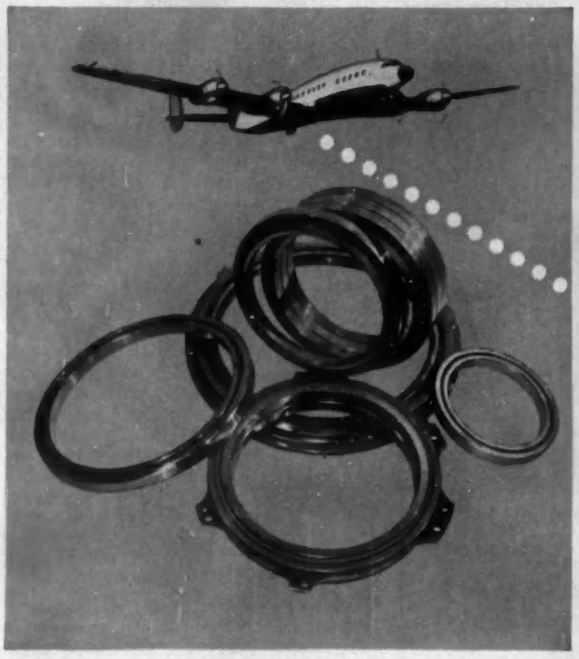

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AIRCRAFT

Ion Thrust Engine Development, D. L. ESCHNER. Paper No. S98 presented April 4, 1958. (Metropolitan Sec). Of four basic propulsion methods (chemical, heated gas, electric and photonic), only chemical system is primary power source; ion generation; thrust unit development study for space cruiser will be divided into two parts: establishment of design criteria for anode; construction of ion source and accelerator for generated ions; two problem areas indicated.

FUELS AND LUBRICANTS

Status of Automotive Rear Axle Lubricants, C. R. NOLL. Paper No. S108 presented May 1958 (Metropolitan Sec.), 9 p. Review of efforts to improve lubricants; tests devised to define satisfactory performance with reference to new proposed Ordnance Department specification; analysis of 100 samples of improved GL4 lubricant, taken from Army vehicles in tests at Yuma, Ariz., shows that after short periods of use severe disturbance of original balance between effective chemical constitutents of additives used occurs; recommendations made.

Lubrication of Railway Journal Roller Bearings, P. C. PATERSON. Paper No. S99 presented Mar. 1958 (Chicago Sec.), 22 p. Review of experience from early installations to present time; past and present practices; requirements and desirable characteristics of lubricants; application of roller bearings to main line freight cars; reference to Timken heavy duty type AP all purpose roller bearing assembly and its applications; lubrication features.

Low Temperature Behavior of Motor Oils—Study of Dependence of Cranking Speed on Motor Oil Viscosity, T. W. SELBY. Paper No. S104 presented Mar. 1958 (Chicago Sec.), 28 p. Comparison of results of 250 cranking tests conducted at temperatures from +3 to −35 F; results compared using viscosities as determined in moderate shear viscosimeter and as extrapolated and calculated by ASTM chart, and recently published analytical technique.

Octanes from Motor Oils, M. L. KALINOWKSI, L. D. LA CROIX, R. A. NEJDL. Paper No. S102 presented Mar. 1958 (Chicago Sec.), 14 p. Motor oils contribute to combustion chamber deposits, therefore to octane requirement increase (ORI) and surface ignition; study of separate components of oils in laboratory engines shows that base oils add largest increment to ORI, viscosity index improvers less, and detergents and inhibitors least; surface ignition reduced by phosphorus, barium, calcium, and zinc.

Lubrication of Outboard Motors, W. C. CONOVER. Paper No. S101 presented Mar. 1958 (Chicago Sec.), 6 p. Growth of outboard motor industry in last 7 yr; use of air cooled engines using 2-cycle principle for chain saws, lawn mowers, generators, scooters,

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washing machines, etc.; theory of lubrication of 2-cycle engines; it is felt that oil companies could make improvements in their basic research; specification of main properties of good outboard motor oil.

Engineer Looks at Industrial Lubrication, B. M. DUNHAM. Paper No. S100 presented Mar. 1958 (Chicago Sec.), 8 p. Developments and methods to accommodate machine design advances in evolution into automation related to lubricants and their significant properties as associated with plant lubrication in automotive industry; three groups of machines considered, machine tools, presses, and welders; requirements of plant lubricants, and recommendations for machine tools.

GROUND VEHICLES

Wisconsin Engines for Refrigeration Equipment, F. B. ESTY. Paper No. 58A presented June 1958, 8 p. Types of Wisconsin Motor Corp. internal combustion engines used in providing refrigeration and air conditioning for road vehicles; refrigeration units requiring engines up to 18 hp; units placed under trailer for engines up to 30 hp; units in front of trailer having engine equipped with starter and generator and thermostatic control.

Evaluation of Lap-Type Automobile Safety Belt with Reference to Human Tolerance, J. P. STAPP, D. L. ENFIELD. Paper No. 62A presented June 1958, 12 p. Basic criteria, human and mechanical factors to consider in design of belt and its performance; analysis of body displacements, decelerative forces and body reactions to restraint; recommendations for automotive safety belt standards and modification of vehicle interiors.

Automobile Barrier and Rear-End Collision Performance, D. M. SEVERY, J. H. MATHEWSON. Paper No. 62C presented June 1958, 61 p. Analysis of relative collision characteristics of unit body and frame type construction vehicle in collision experiments using human and anthropometric dummy subjects for evaluation of force and related injury causative factors; vehicle and occupant deceleration-acceleration patterns; deformation comparisons; evaluation of interior design and protective devices; cost to repair damaged vehicles.

Preliminary Report on Automobile Side Window Glass — Study of Glass Damage and Associated Occupant Injury in 715 Accidents, B. TOURIN, J. W. GARRETT, J. O. MOORE. Paper No. 62E presented June 1958, 24 p. Nature, scope and results of study, undertaken by Automotive Crash Injury Research; findings do not imply necessity to deal separately with specific make or year of car; observations deal with gross bodies of data such as cars with damaged wide window glass, without damage side window glass and all cars in sample.

Driving Simulator, J. L. GODDARD, B. H. FOX. Paper No. 62B presented June 1958, 13 p. Formulation of requirements of simulator to be developed; deficiencies of devices constructed for traffic accident research to study behavior of average driver; psychological and engineering considerations; combination of techniques suggested using films, point source of light and models; data processing of acceleration and electroencephalographic response of driver; feasibility of simulator under investigation at Cornell Aeronautical Laboratory.

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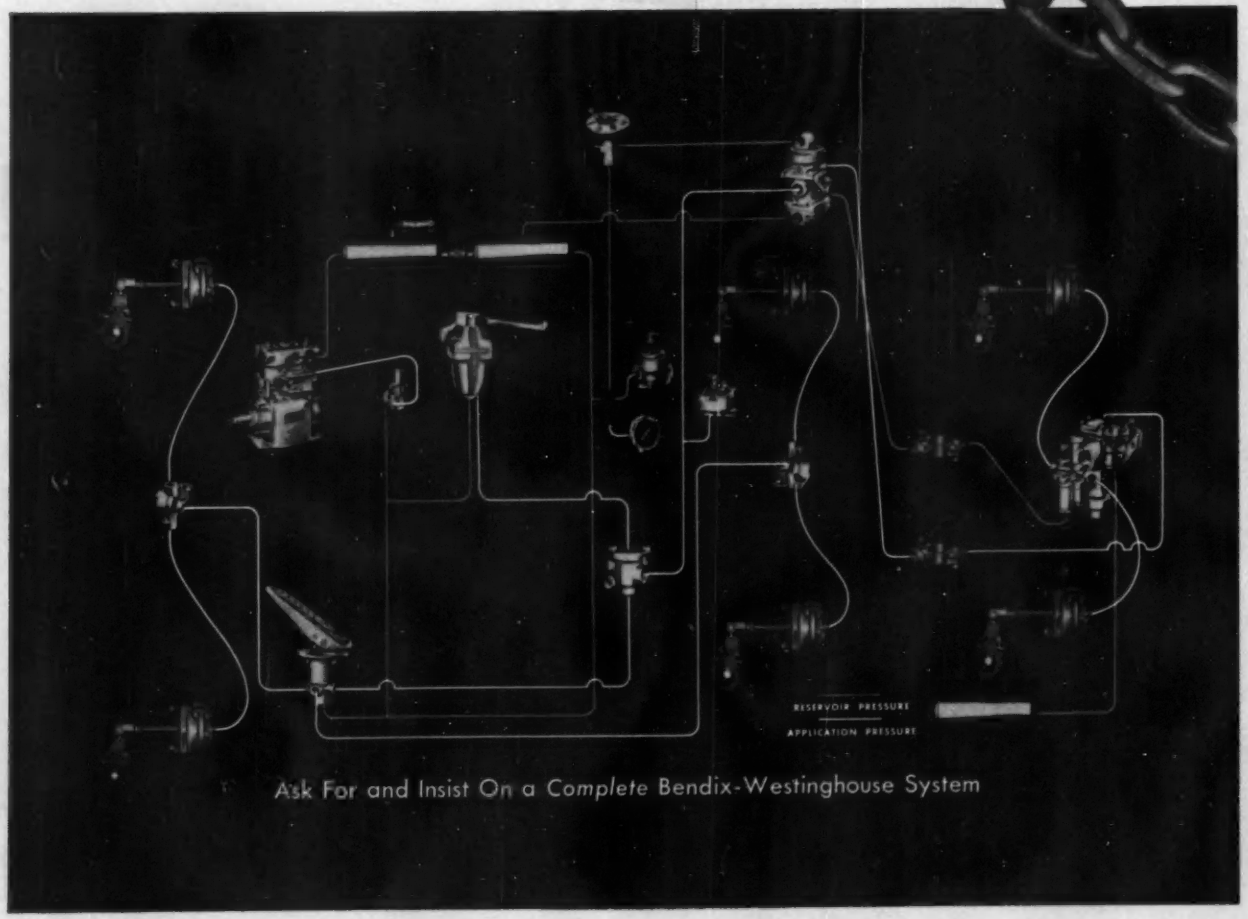

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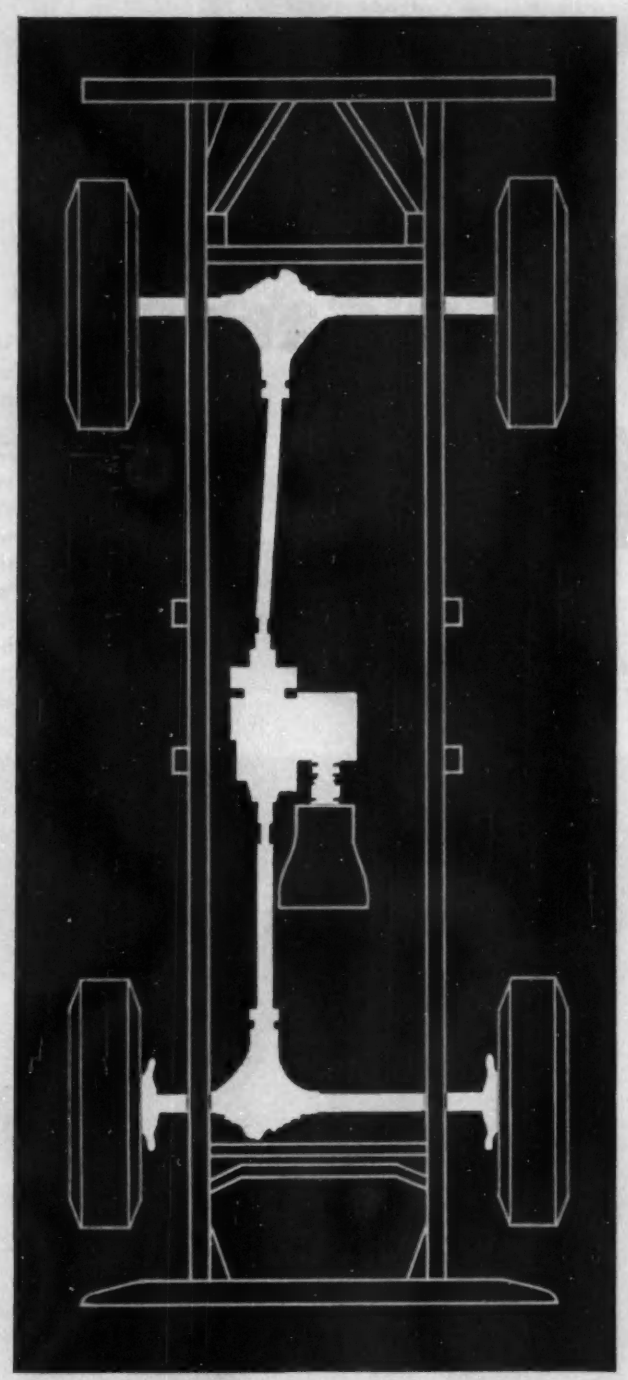

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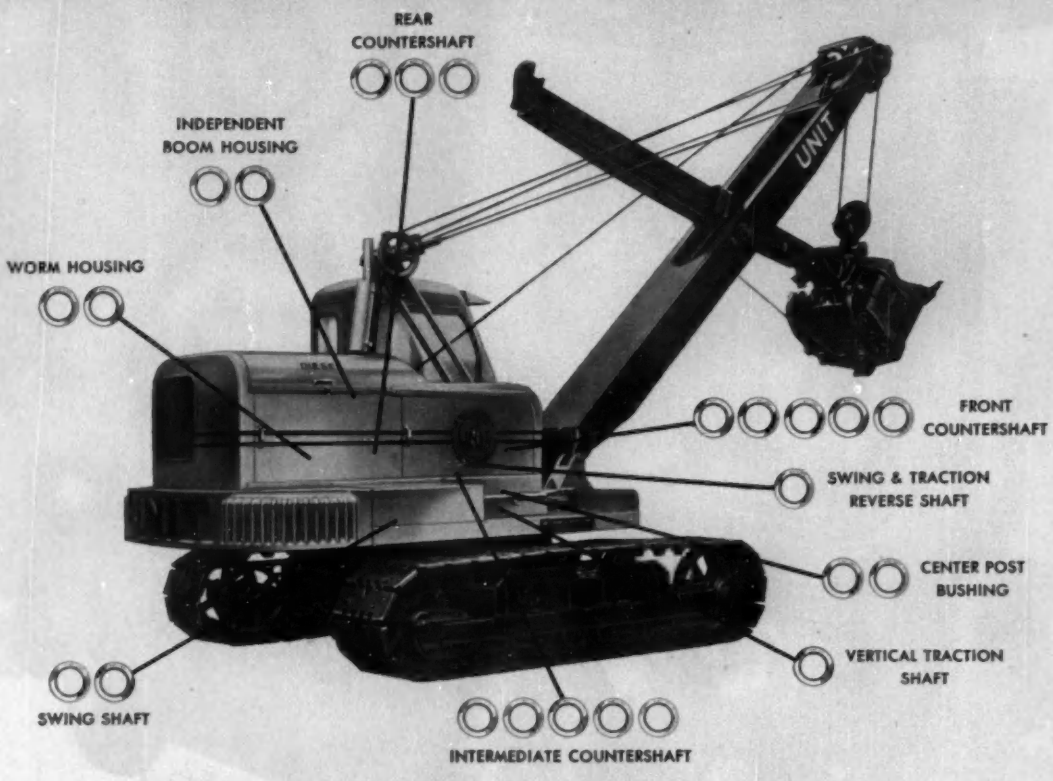

National Oil Seals used at key points throughout UNIT Crane & Shovel excavators

UNIT Model 1020 pictured above is a ¾ yard diesel excavator designed for maximum convenience and versatility in medium-duty applications. As in other UNIT excavators, National Oil Seals are installed at key points to retain lubricant, exclude dirt and water, and prolong life of bearings and assemblies.

In the UNIT 1020 Excavator, a total of 23 National Seals are employed in 9 basic subassemblies. These include front, rear and intermediate countershaft assemblies, swing traction reverse shaft, the turntable center pin assembly, vertical swing shaft, worm housing and traction shaft assemblies.

Grease seals used in the Model 1020 are of the National 50,000 series design, employing a spring-tensioned leather sealing member mounted inside a precision-made steel outer case. Shaft sizes range from 11/16" in the intermediate countershaft assembly to 8" on the turntable center pin. Similar use of National Seals is made in 11 other excavators offered by UNIT.

National Seals used in the UNIT Model 1020 are all of standard design; National offers over 2,500 different such seals or can design special seals for special requirements. Call your National Applications Engineer. He's listed in the Yellow Pages, under Oil Seals.

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This advertisement appeared in the following journals: Autocar, Automobile Engineer, Motor, Motor Industry & Motor Trader.

"HIGH QUALITY EPOXY TOOLING AT LOW COST"

AVCO *Speeds ICBM Nose Cone Development With Unique Checking Tools Made of*

RCI Epoxy Resins and Polyurethane Foam

"In producing experimental missile components, we need a fast, foolproof and economical method of checking accuracy. And Reichhold EPOTUF epoxy resins have played a major role in our development of just such checking units."

Speaking is Mr. Bob Thompson, Plastics Project Leader, Experimental Manufacturing Department, Avco Research and Advanced Development Division, Lawrence, Massachusetts.

Avco's experimental work on the Titan ICBM nose cone is a vital, high priority project. Complex parts must meet exact tolerances. The slightest imperfection might cause failure.

For instance, one length of pipe for the nose cone twists and turns sixteen different times in its 34-inch length. To test the accuracy of each bend, Avco has developed tools such as you see above made of RCI epoxy resins and RCI polyurethane foam. Such devices can be made quickly and inexpensively, and solve one of Avco's toughest testing jobs.

"Furthermore, another benefit we gain in dealing with RCI is invaluable technical aid," Mr. Thompson stated. "Also we have never experienced any delays in delivery... and we absolutely need this kind of service."

Perhaps dependable, versatile RCI EPOTUF epoxy resins or RCI POLYTOOL plastic tooling compounds will improve *your* application. Write RCI for details.

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Synthetic Resins • Chemical Colors • Industrial Adhesives • Phenol
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The many ways urethanes can be fabricated . . . molded, foamed in place, bonded to structural frames or outer coverings, cut, sewn, tacked or hog-ringed . . . suggest new cost-saving production methods that are well worth your investigation.

As makers of NACCONATE® Diisocyanates, essential urethane components, we will gladly work on application development with automotive engineers, designers and suppliers. For information, write National Aniline.

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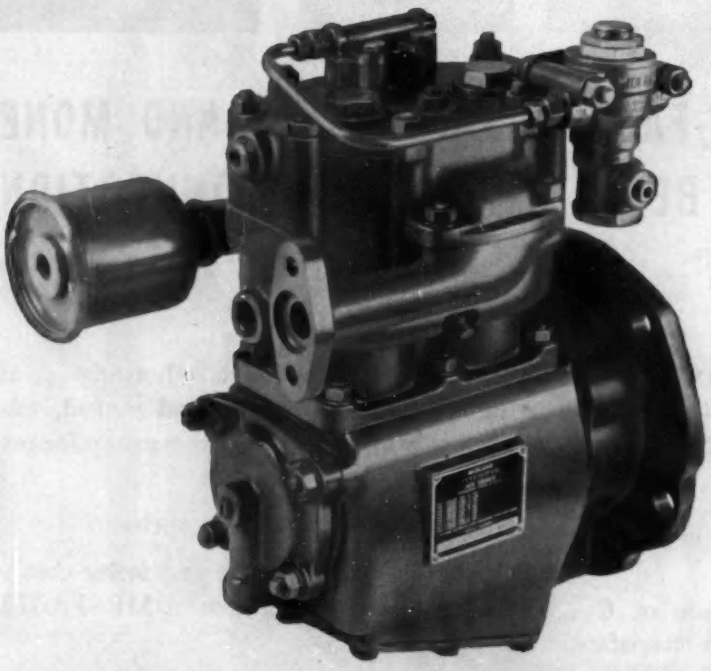
Midland Compressors reduce oil passage to a minimum . . . so, no carbon, no headaches . . . In short, Midland Air Compressors have all the advantages anyone who needs compressed air could hope to have in *one* product: (1) less power required per cubic foot of air; (2) no oil-passing worries; (3) cooler operation; (4) governor mounted on compressor itself for simplicity; (5) lighter weight; (6) so easy to install; (7) maintenance a cinch (only 1 simple adjustment to control reservoir pressure range) . . . Man, what a compressor! Your nearest Midland Distributor (they're everywhere) will be happy to give you the complete story . . . or you may contact the factory direct.



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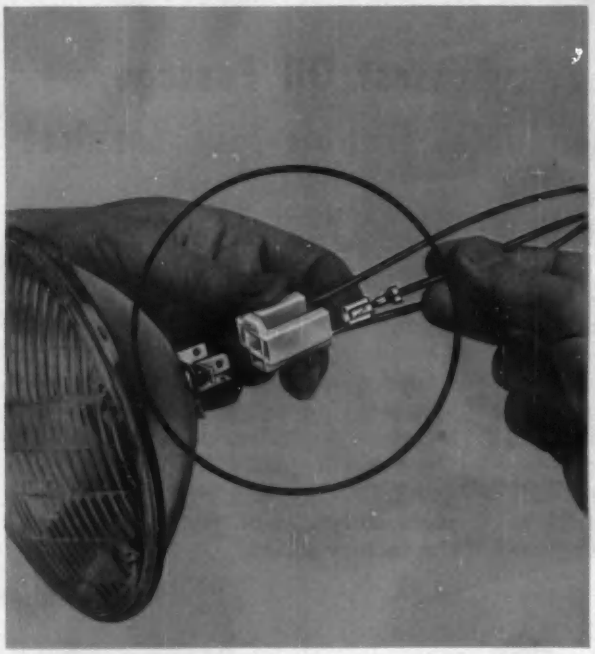

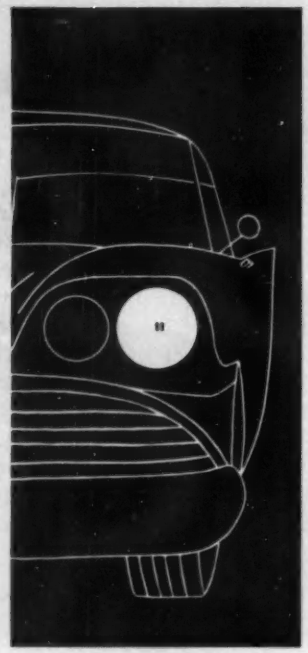

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FASTIN-FASTON housing made of Cycolac for excellent dielectric characteristics.

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Unvarying performance and lower cost . . . a snap for the all new A-MP FASTIN-FASTON.

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to solve your individual problems.

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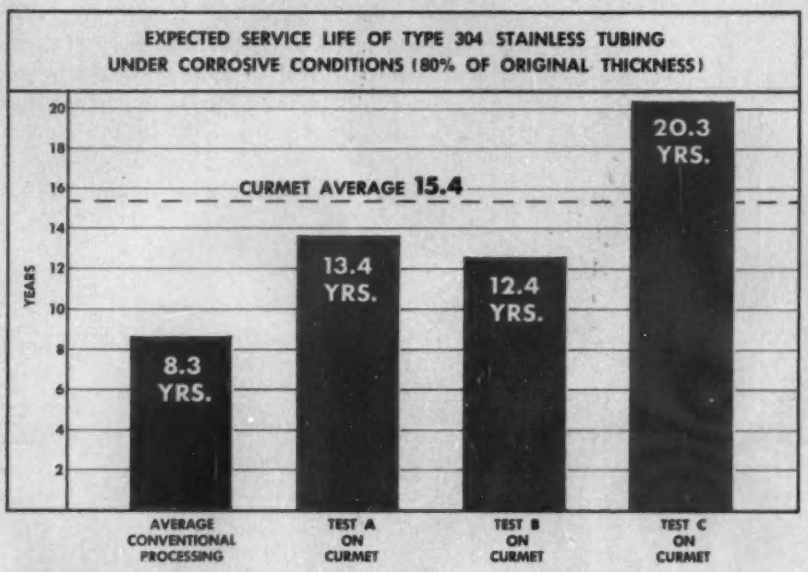

Tests by three CURMET customers* confirm the findings of Curtiss-Wright's own Metals Processing Division laboratories: CURMET extrusion imparts substantially greater corrosion resistance to stainless steel alloys.

For the results shown graphically above, test samples of conventionally wrought and CURMET extruded material were subjected to the standard boiling nitric acid (Huey) test in accordance with ASTM specification A-262.

The tests were made in relation to requirements for nuclear power installations of tubing and fittings. The increased service life that can be expected with CURMET processed stainless is attributed to a homogeneous micro-structure not attained by other methods of conversion. It is achieved at no sacrifice in tensile strength, ductility, impact strength or other property affecting performance of the product.

*Names on request

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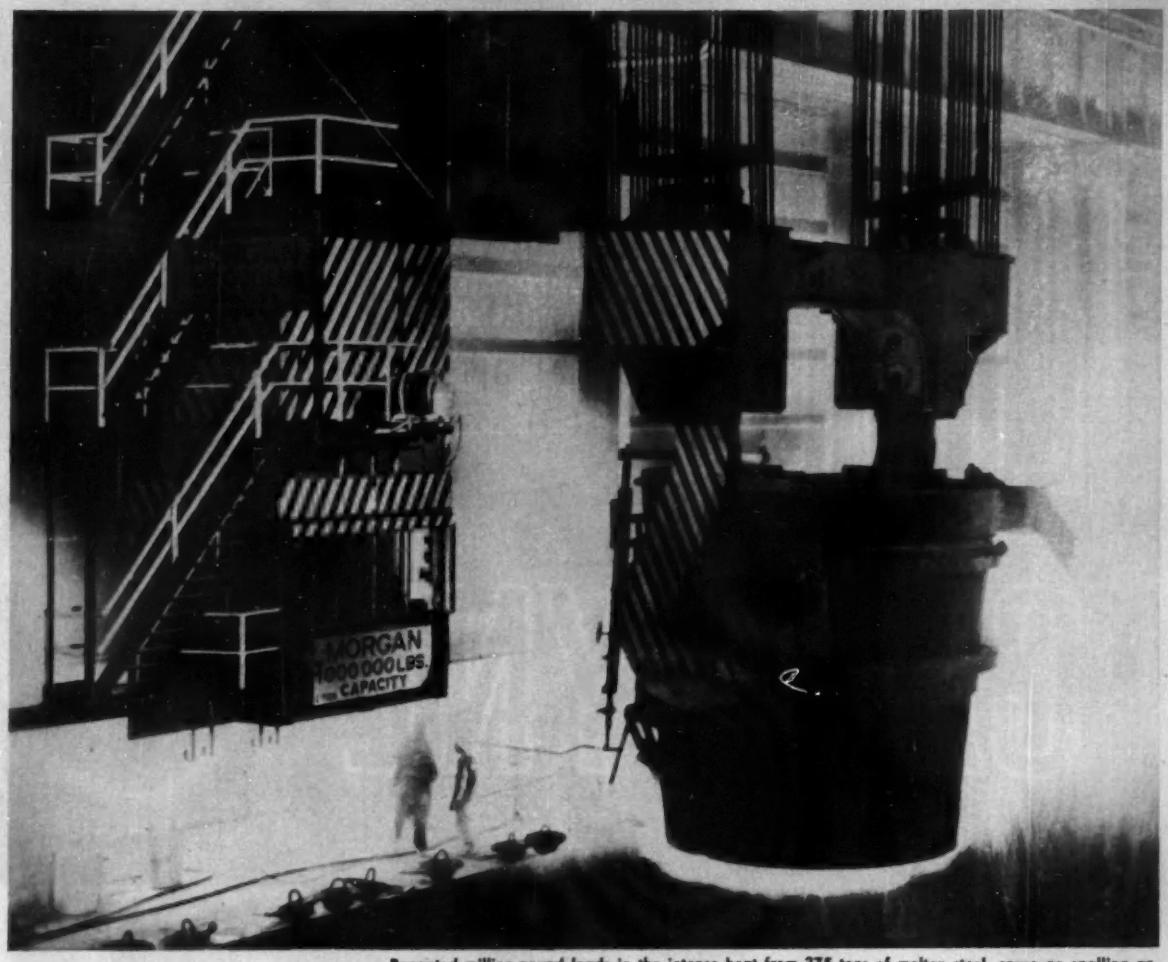


Repeated million-pound loads in the intense heat from 375 tons of molten steel, cause no spalling or deformation of Rollway Bearings.

1,122,000 Pounds Ride on 68 Rollway Bearings

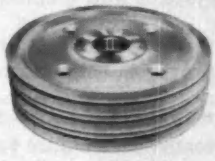
One of the largest in the world, this 500-ton Morgan-built ladle crane is Rollway equipped in many positions.

Sixty-eight maximum-type, solid-cylindrical bearings—mounted without inner races—lift and lower the 1,122,000-pound weight of the lifting beam, ladle hooks, ladle and white-hot steel.

Rollway Tru-Rol® type bearings are used in the two General Electric 360 HP – MD-620 Hoist motors which lift the weight of the ladle and its molten metal content.

The maximum-type bearings in the hoisting sheaves are mounted directly on the shaft without inner races, which greatly simplifies assembly for applications of this size.

Thrust bearings in the 25-ton and 75-ton auxiliary crane hooks are standard Rollway precision types with broad-area contact between rollers and plates to prevent Brinelling and assure freedom of rotation under the heaviest loads.



Sheaves ready for assembly on shaft and installation in lifting beam.

For bearings that accomplish the extraordinary in an ordinary manner, write, wire or 'phone Rollway Bearing Co., Syracuse 1, N.Y.

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LING ELECTRONICS, INC.
... leader in the manufacture of high-power, electronic vibration amplifiers and vibration control systems.

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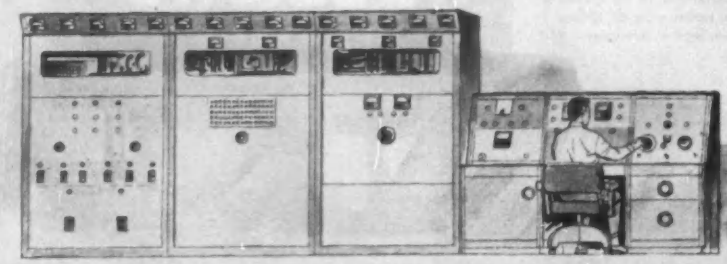

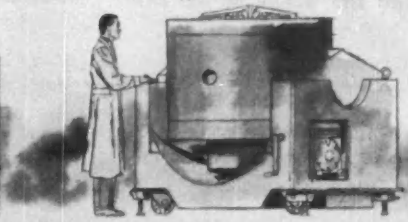

...for as little as $148.50

New K&E Paragon Auto-Flow gives you faster, easier drafting 5 ways...

The first time you use it, you'll know that K&E's light-weight Paragon® *Auto-Flow*™ Drafting Machine is a truly great advance in working ease and range. Here are 5 *specific* reasons why.

It's more versatile. Stays in perfect balance at any board angle, from vertical to horizontal. No adjustments needed, except a simple turn of a tension spring wheel for angles below 15 degrees.

It's more compact. The balance is built right into the machine itself. There's no need for counterbalances that project over the top of the board.

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It's far easier to use. The scales move smoothly, at the slightest touch. Long lines up or across can be drawn in a single motion. Scales lock in place to eliminate "drift". Greater rigidity produces truer lines.

The 30" by 40" *Auto-Flow* costs only $148.50 . . . the 36" by 60" only $160. All standard sizes; left-hand models available. Mail coupon for details. 1269

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☐ Please send information on the new K&E Paragon *Auto-Flow*. ☐ Please arrange a demonstration for me.

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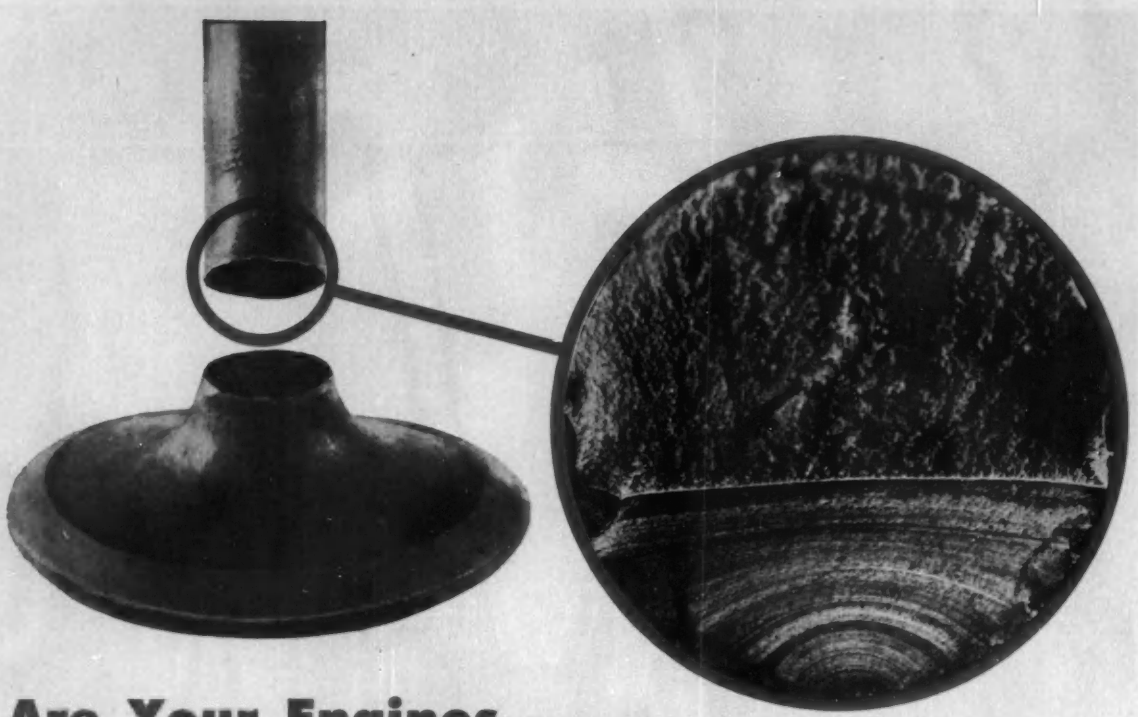
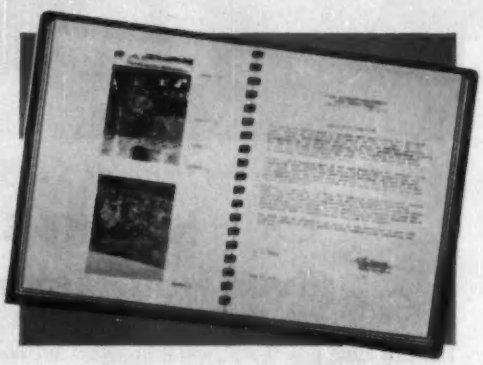


Are Your Engines Plagued by Failures Like This?

Eaton Engineers Can Help You Solve This Problem

The photographs above illustrate a typical fatigue-type failure caused by overstressing, in which fracture starts at the surface and, with repeated high stress, progresses to final break.

If you are an engine manufacturer and are having valve gear problems, Eaton engineers will be glad to consult with you and recommend procedures to help solve them. Or if you are designing new engines, perhaps our past valve experience can be valuable to you. Write, wire, or phone — there's no obligation.



Eaton Technical Reports are Available to Manufacturers

Eaton valve engineers will be glad to make a thorough study for you and furnish a complete technical report.

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For the Sake of Argument

Forget . . . Or Never Know?

DID I FORGET what the man said . . . or did I ever really know? Did I interpret that report inaccurately because I forgot some facts . . . or because I never really got them straight to begin with?

We often make memory a scapegoat for inattention, lack of concentration. Because "everybody forgets sometime," we'd rather admit to a faulty memory than to faulty intake of information.

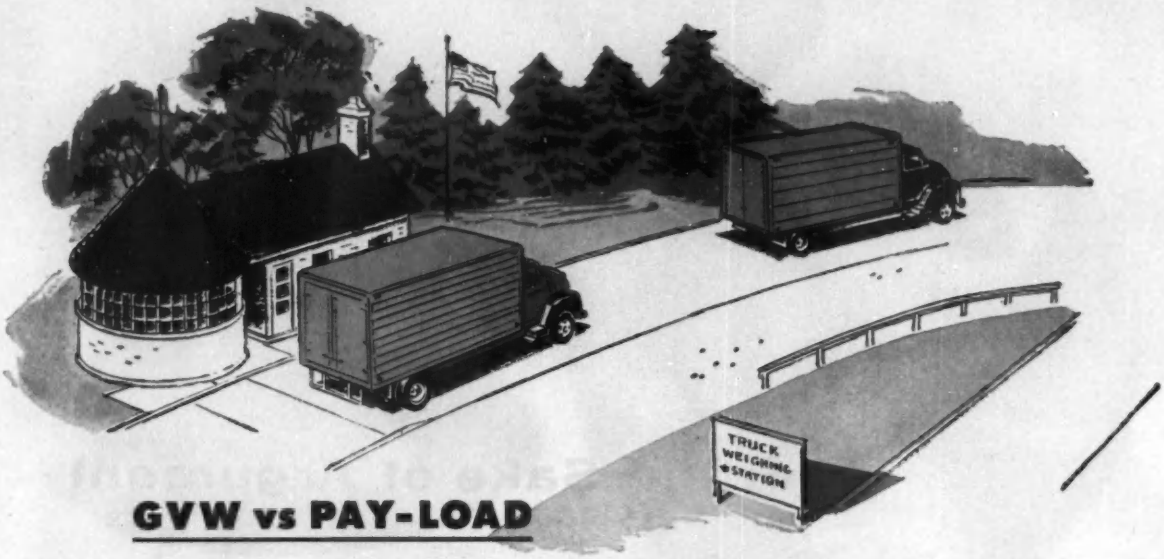
Actually, failure to focus facts or concepts for one's own keeping is as common as plain forgetting. Besides, it causes considerably more confusion in business relationships.

When we know we've forgotten, either we say so or throw up easy-to-read "NOT SAFE" signals for our listeners or readers. "If I recall correctly . . . ," "My understanding of his concept was . . ." and similar phrases warn associates to proceed with our "information" at their own risk.

But when we do remember clearly ideas or data which we have "copied" inaccurately on the tablet of our mind, we may speak with a sureness that leads others astray. The business devastation that can be wrought by self-assured ignorance is fearsome to contemplate.

Perhaps we should regard all ideas and information as we would foreign languages, when first we hear or read them. Recognizing the need for careful translation might stimulate our minds to more accurate recording . . . or at least to full awareness of the quality of our intake.

Norman G. Shidle



GVW vs PAY-LOAD

WHERE A POUND SAVED IS A DOLLAR EARNED!

By saving dead weight, vacuum power can add several hundred pounds to pay-load, and earn extra dollars, as ton-miles build up.

In addition there is vital safety in having physical braking instantly available should power fail for any reason.

For these and other important reasons, vacuum power is the overwhelming choice on trucks, and HYDROVAC* leads all other makes combined.

...It will pay you to look into

HYDROVAC (VACUUM HYDRAULIC) POWER BRAKING BY BENDIX

*REG. U.S. PAT. OFF.

Bendix PRODUCTS DIVISION South Bend, IND.

Bendix AVIATION CORPORATION

chips

from SAE meetings, members, and committees

NEAR EAST OIL is a drop in the bucket compared to the immense oil shale reserves underlying Spain, France, England, Belgium, Holland, Germany, Denmark, Sweden, and other Baltic countries, says Dow Chemical's John J. Grebe . . . and it may be possible to nuclear bomb these reserves to productivity in the next 20 years. (See "COMING: Nuclear Bombing for Depleted Oil Wells", pages 30 and 31 of this issue.)

SOME 1100–1200 AIR FORCE AIRPLANES are airborne at any one time, Maj.-Gen. Joseph D. (Smokey Joe) Caldara, USAF writes. The airplanes average 14,750 miles every 60 sec. That distance is more than half way around the world.

USAF accident record is improving, Caldara says. In the first six months of 1958 there were only 10.7 major accidents per 100,000 flying hours. Figure he gave for 1957 in a speech to an SAE audience was 13.6.

Joy has a way of eluding us whenever we do less than the best we know how.

DISCUSSING new high energy particle accelerators at an SAE Nuclear Energy Advisory Committee meeting, one member asked, "What are the problems that justify 9th or 10th power dollars"?

A HEAD-ON COLLISION is almost impossible to avoid in today's 600 mph aircraft. Reason: — Time runs out before the collision can be avoided if the pilot has no anti-collision warning device. The time-table for death looks like this:

- Two to three miles away the pilot first spots the oncoming plane. This short spotting distance is probably due to the pilot's eyes focusing at a point a couple of feet in front of the wind screen — probably because there is no background at high altitude.)
- Four seconds are left before impact after the first spotting.
- Perception, and recognition of a collision course takes 6/10 of a second.
- Decision to act takes at least another whole second.
- Moving his hands and feet takes the pilot another 4/10 sec.
- Control reaction time and time for flight deviation takes more than the two remaining seconds.

THE LOAD DOESN'T CARE what kind of powerplant provides the power as long as it does the job, says Caterpillar's W. J. Lux.

"Users needn't concern themselves with whether the engine has a turbocharger or whether it turns out power with the aid of mirrors, nuclear energy, or cosmic rays . . . so long as it produces the power required for the job from a package of the size, weight, AND COST that is economically competitive with any other means of doing the same thing."

EACH JET TRANSPORT will require about 4 million gallons of fuel per year, on the average. At least this is the quotient of one fleet's anticipated annual volume divided by the anticipated number of aircraft in the fleet. Estimates voiced in SAE meetings a year or two ago ran as high as 6 million gallons.

MANY SAE AUTHORS will have international distinction judging from the number of requests for reprint permission that have been received in approximately the last 12 months. Twelve foreign countries have requested permission to reprint 31 SAE Journal articles. They are Argentina, Australia, Belgium, Brazil, Canada, England, France, Germany, Holland, India, Italy, and Mexico.

Tomorrow's victories must be won today.

MILITARY FLYING is getting safer, but we have still lost over 2700 pilots in the last seven years. The major accident rate has dropped from 506 to 13.6 per 100,000 hr flying time in the span of years from 1921 to 1957. However, the accidents are more violent as witnessed by the fatalities per accident. Twenty-five years ago one person died for every 13 accidents. By 1957 the ratio had jumped to one for three.

Pilot error and material failure lead the list of accident causes. The first accounts for 53% and the second for 40% of all major military accidents.

TOTAL VALUE, without spares, of the aircraft now on order for delivery by the end of 1961, both turbine and piston-engined, is in the neighborhood of $3,000 million, it is estimated in the report of an International Civil Aviation Organization committee. The report points out that figure is almost equal to the total list price value of the transport aircraft in service in mid-1958. The total list price value as of June 1958 is calculated to be about $3,-100 million.

why the

is easy to maintain in the

Based on paper by

R. W. Manley

head of systems engineering department
Guided Missiles Laboratories, Hughes Aircraft Co.

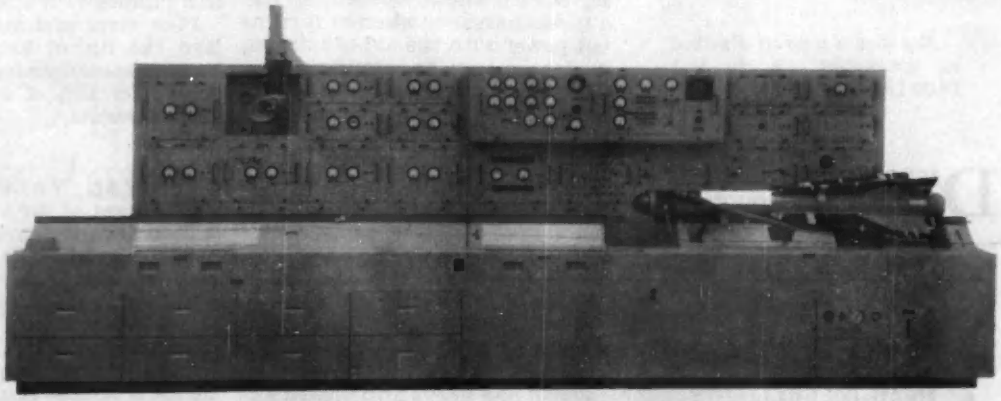
THE production Falcon missile design consists of 10 field-replacable units housed in the airframe. Certain of these can be replaced in 5 min or less. Others take 30 min or so. However, the units that take some time to replace are units that seldom fail. One of those units is the rocket engine, which may possibly have to be replaced because of age but which never fails during storage.

Easy accessibility to test points for all circuitry requiring field tests is assured by use of two plugs. One of these plugs is the regular umbilical plug provided at the surface of the missile for those leads which must be connected to the missile at the launcher. The second plug is a test access plug for those leads which have to be available only for field tests. It is covered by an easily removable hatch.

The production missile is generally easy to disassemble and reassemble for maintenance. About 27 different tools are required for use with the various units and bits and pieces which may require field replacement. Only eight of the tools are special tools.

The field checkout console is designed so that all major electronic portions are built up as plug-in packages. The packages are mounted on rails and secured in place by thumb screws. When a package is pulled out on the rails, circuit plugs automatically break. It takes only about 1 min to replace a package.

The console provides for straight-line flow. The missile is put on a roller conveyor at one end of the console and is moved through successive work stations for partial disassembly tests and reassembly. The missile emerges from the console completely "live" and combat ready. It is hoisted on and off



MISSILE CHECKOUT CONSOLE simplifies work of insuring that Falcon is combat ready. Missiles are checked out on receipt at the base and stored in this "live" condition until a requirement exists to load them on interceptors as armament. Missiles in "live" storage are checked out periodically to assure that combat readiness has not deteriorated during storage. Missiles are also checked out when down-loaded from the aircraft for any reason, such as routine aircraft maintenance.

The test equipment is reparable by substitution of plug-in packages. At each location sufficient spare packages are available to allow replacement of a faulty package and continuance of the test equipment in service. Faulty packages are repaired at the squadron maintenance area.

Falcon field

the console by electric hoists having tongs which grip prescribed surfaces of the missile. Maintenance workers don't have to lift the missile at all in the checkout process.

Field experience with the Falcon has taught us these lessons, which can be applied to other missile programs:

1. A realistic test of maintainability can be made only in the tactical environment with personnel of user skills. What is easy or normal for an engineer may be difficult for the Air Force technician who has had little technical training prior to his service. In the case of the Falcon, the first maintenance procedure worked out proved too complicated for the user to apply.

2. There should be a minimum of adjustments to be made when plug-in units are replaced in the field. The more adjustments to be made, the greater chance for confusion and the more complicated the test procedure.

3. It is just human nature to want to turn adjustment screws. Access for adjustments that are to be made at the factory or depot—and not in the field—should not even be visible to the user in the field. If adjustment ports for adjustments the technician ought never to make are available to the field technician, mistakes will be made which render good units unserviceable until they are reworked at the depot.

4. There is no substitute for actually building the missile and test equipment, trying it out first on the engineers, and then getting some disinterested person who has never seen the gear before to go through the motions. No matter how carefully the hardware has been designed, the man who is not familiar with it will turn up some simple but important deficiencies in layout or mechanical design. The secret to designing electronic equipment for maintainability lies almost entirely in good mechanical design.

5. It is vitally important to explain to the user just what is inside black boxes, especially black boxes which the user knows contain explosive or hazardous material. Nothing is so bad for morale as a package which is known to contain explosives but about which little else is known. In the case of the Falcon, a certain black box is fail safe in every respect during handling. But the fact that in the early days of field use no explanation of the contents of the sealed package was available made the users shy of it. Any small difficulty with this package immediately resulted in a suspension of operations until the situation was clarified. Education in this realm can save a lot of confusion.

6. The failure-report form must be simple to fill out, but it must tell the complete story. In the early days of the Falcon, units would be returned with the notation that they had failed, but without explanation of the nature of the failure. If symptoms had been known more completely, more effective remedial action could have been taken earlier. An adequate failure reporting system at the beginning of field use certainly expedites recognition and solution of problems.

7. There is no substitute for actual field tests of equipment. Inevitably some important feature will be overlooked during design, and the oversight revealed only by field tests. The earlier equipment and missiles are fabricated and put to field tests, the earlier the problems will be known. Simulation of field conditions right down to actual buildings and personnel is the only effective means for field test.

To Order Paper No. 93C . . .
. . . on which this article is based, turn to page 6.

97+ Octane Fuels Give Best Mileage Economy

Existing refinery and modern car data give a most-miles-per-dollar curve which peaks at around 97 octane. Continued developments in the petroleum and automobile industries are needed to raise substantially the optimum octane number.

Based on paper by

F. W. Kavanagh, J. R. MacGregor, R. L. Pohl, and M. B. Lawler, California Research Corp.

THE MOST MILES for the dollar comes from the modern car that uses 97 + octane-number fuel, present calculations show. This is the point at which increased efficiency from high compression ratios runs into the rising cost of high-octane fuel.

Calculations made at California Research produced the miles-per-dollar versus octane-number curve shown in Fig. 1.

The public hasn't been faced with high cost for octane numbers in the past because the chemical processes developed in the '20's were designed to produce more gasoline from crude stocks. The fact that the octane number was also increased was an advantageous byproduct. Now, the newer processes do not make more gasoline, they just reform existing gasoline into a higher-octane-number product — and the costs are all chargeable to the octane numbers. Unless there is a substantial improvement in manufacturing processes of gasoline — or a radical change in engine design, the cost-per-mile picture should stay the same.

behind the calculations

Widely varying results can be found in a country-wide analysis if base lines or assumptions are changed. The two main points assumed in the California Research study are:

- Existing refineries would be modified to produce high-octane gasoline.
- All performance benefits are taken as increases in mileage economy.

In making the calculations, the steps used to predict the cost of an octane number were:

(1) A typical U.S. refinery with an output of 100,000 BPCD is assumed to exist and produce gasoline by: crude distillation, two-stage catalytic reforming, fluid catalytic cracking, thermal cracking of residuum and cycle oil, butene alkylation, and propene-butene polymerization.

(2) Units are added to improve octane number by reformate splitting by distillation, increasing reformer severity, alkylation of butenes formerly polymerized, new high-severity catalytic reforming, and pentane isomerization.

(3) Increased costs of manufacture were added directly to the retail price.

(4) Gasoline produced would maintain the present 30–70% spread between usage of premium and regular gas. The octane-number spread between the two grades was also kept constant.

In figuring the effect of higher compression ratios on cars, the following data or assumptions were used:

a. Compression ratios were adjusted to take full benefit of the gasoline.

b. Highway and city driving tests were run on eight late-model cars. Results were checked against data from other laboratories for highway driving.

c. Compression ratio versus mileage figures of test cars were adjusted to match the published data on 1957 cars and these results were weighed by national registration figures.

d. U.S. Bureau of Public Roads averages were used for percentage of city and highway driving.

e. The CRC method of determining 90% satisfaction was used.

The overall results of the car and refinery calculations are shown in Figs. 2 and 3.

effect of base-line assumptions

The optimum octane number of 97 can be moved up or down by changing the base-line assumptions. By deliberately doing this, the sensitivity of the cal-

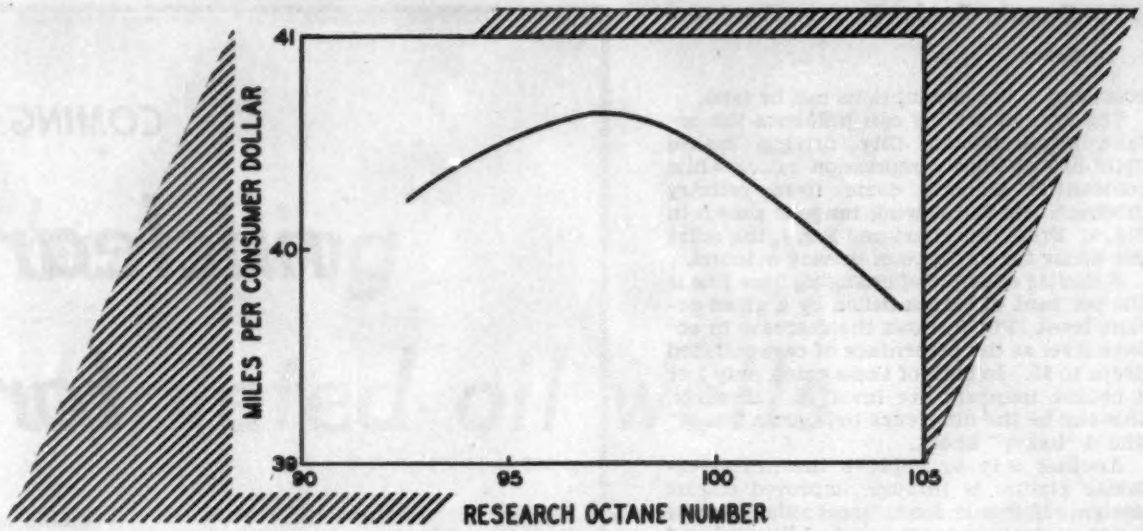


Fig. 1 — Most miles per dollar results from a 97 Research octane-number fuel and a car with a matched compression ratio.

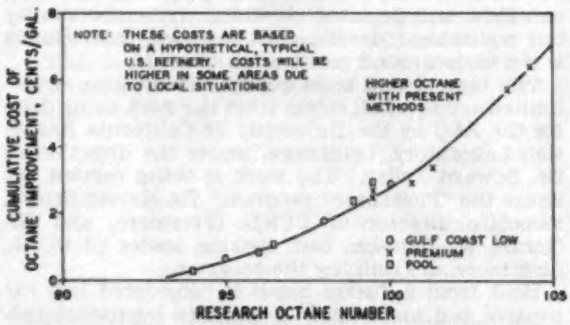


Fig. 2 — Cost of adding "octanes" to premium gasoline climbs rapidly when thermal and catalytic reforming processes are used. Cost may be higher than shown if additions to present typical refineries do not make full utilization of existing equipment.

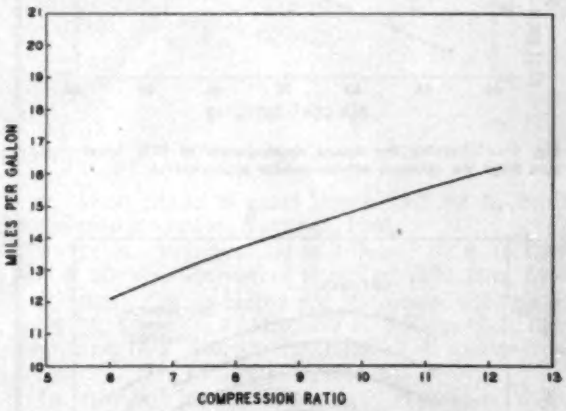


Fig. 3 — Improvement in fuel mileage with compression ratio is shown for typical car under average driving conditions. This graph and Fig. 2 combine to give the miles-per-dollar chart shown in Fig. 1.

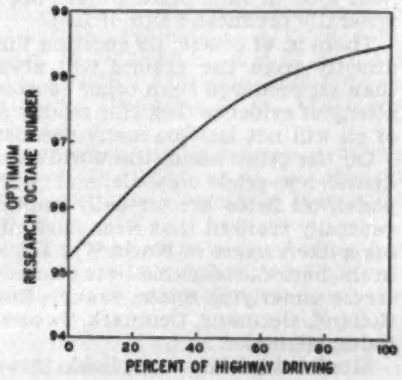


Fig. 4 — All-city or all-highway driving only changes the optimum octane number ±2.

97+ Octane Fuels

. . . continued

culations to the assumptions can be seen.

The type of driving can influence the octane requirements. City driving makes little use of high compression ratios while substantial benefits come from country driving. The full driving range is shown in Fig. 4. From this chart and Fig. 1, the miles per dollar for any type of driving is found.

A similar example of changing base line is the per cent of cars satisfied by a given octane level. Fig. 5 shows the decrease in octane level as the percentage of cars satisfied drops to 50. In both of these cases, only 3 or 4 octane numbers are involved. However, this can be the difference between a "trace" and a "heavy" knock.

Another way to improve the miles-per-dollar picture is through improved engine design. If this is done, "mechanical octane numbers." will lower the cost of the fuel and give more miles per dollar, as indicated in Fig. 6.

To Order Paper No. 748 . . .
. . . on which this article is based, see p. 6.

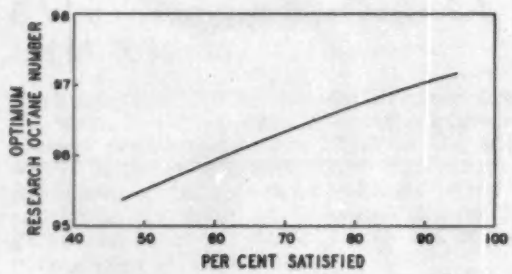


Fig. 5 — Satisfying the octane requirements of 40% fewer cars drops the optimum octane number approximately 1½.

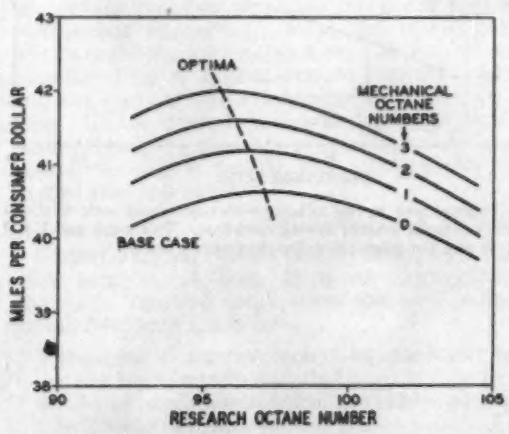


Fig. 6 — Engine designers can help the mutual octane number-compression ratio problem by improved designs. "Mechanical-octane numbers" don't change the shape of the curve, but do give more miles per dollar.

COMING:

nuclear for

Reported by
John J. Grebe
Member, SAE Nuclear Energy Advisory Committee

NUCLEAR explosions, particularly fusion as developed in bombs, are being carefully studied as a means of making available usable oil from oil shale, tarsands, and depleted oil wells. (Another similar but nonnuclear development reported from Russia is the underground gasification of coal.)

The biggest and most potent reassurance of unlimited supply of oil comes from the work being done for the AEC by the University of California Radiation Laboratory, Livermore, under the direction of Dr. Edward Teller. The work is being carried out under the "Plowshare" program. Dr. Harold Brown, associate director of UCRL, Livermore, and Dr. Gerald W. Johnson, test division leader of UCRL, Livermore, are running the program.

Heat from a fusion bomb is considered less expensive and more likely to produce byproduct values, and may be used more easily in confined spaces to generate the high temperatures and pressures needed to do this job than any other source of heat controlled by man. A very rough estimate of the cost of production is 4¢ per million Btu. This makes the cost of operation negligible because each Btu of heat used in such underground fire drive processes generally produces 6 Btu of fuel.

There is, of course, no question that oil that flows directly from the ground will always be cheaper than oil produced from other sources. But there is plenty of evidence that this readily available supply of oil will not last too many decades more.

On the other hand, the world's resources of coal, lignite, low-grade oil shale, and oil in nominally depleted oil fields are virtually unlimited. It is not generally realized that Near East oil, instead of being a likely cause of World War III, is merely a drop in the bucket, compared to the immense oil shale reserves underlying Spain, France, England, Belgium, Holland, Germany, Denmark, Sweden, and the other Baltic countries.

Similar deposits are available throughout much of

A feature of the

SAE Nuclear Energy Advisory Committee

bombing depleted oil wells

the rest of the world. Particularly rich reserves have been found in Brazil, the United States, and China, for example.

At present, the development of nuclear explosion devices to make these immense and badly needed resources available is being held back by the sheer resistance to obsolescence of existing methods. There are also widespread fears concerning the hazards and impossibilities of such operations. As Camille Rougeron predicted, however, the use of thermonuclear explosions for such projects may well make rapid advances in the next 20 years.

This is particularly true for countries with a severe need for locally produced liquid fuel. Europe is already in this category and many underdeveloped countries, as they develop, will find themselves in the same predicament.

In the United States, however, the relatively easy availability of satisfactory coal and crude oil makes the urgency a great deal less. The economic inducement, while appreciable, particularly in such high-cost fuel areas as New England, Michigan, and the West Coast, will not provide enough incentive to remove the above-mentioned barriers, at a rapid rate. But when the time comes that these methods are used, the Canadian New Brunswick oil shales can be counted on to become a major source of fuel within easy shipping distance of New England.

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Separate but similar circuits for passengers and crew are a feature of

The Air Conditioning System of the DC-8

Excerpts from paper by

A. A. Hershfield

design engineer, Air Conditioning Section
Douglas Aircraft Co., Inc. (Santa Monica)

THE DC-8 transport has two almost-identical air conditioning systems. Each consists of an air inlet scoop, two cabin turbocompressors, an air-to-air heat exchanger, a Freon turbocompressor with its condenser and evaporator, and a three-port mix valve.

This equipment is located in the "boiler room" in the nose of the airplane. Therefore the fresh air inlet scoops are far from any source of contamination. The cabin air and the Freon vapor turbocompressors are driven by air bled from the airplane engine.

Air is ducted from the inlet scoop to the cabin turbocompressors and then, according to the requirements dictated by the temperature control system, goes directly to the "hot" port C of the mix valve for heating, through the air-to-air heat exchanger to the "warm" port B for reduced heating, or through the air-to-air heat exchanger and evaporator to the "cold" port A for maximum cooling.

Freon system for cooling

Heating is accomplished by utilizing the heat of compression of the cabin turbocompressors. Cooling is provided by the Freon vapor cycle system. Each unit is rated at 13½ tons of refrigeration. The air conditioning system is designed to maintain a minimum of 70 F in the passenger and crew areas at cruise altitude and ambient temperatures as low as –100 F and a maximum of 75 F on a hot day ground condition of 95 F dry bulb and 78 F wet bulb ambient.

controls

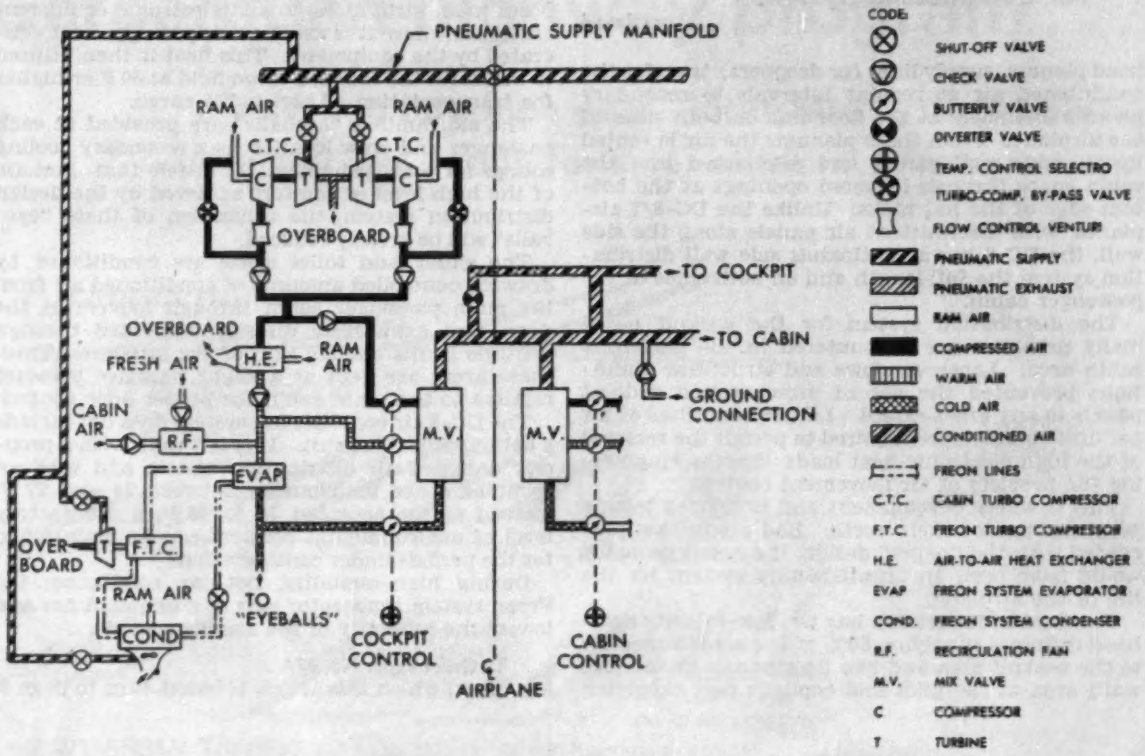
The three-port mix valve is the heart of the temperature control system. It determines the path the fresh air will take prior to entering the occupied space. For example on a hot day the temperature control system will open the port A and allow the air from the cabin turbocompressors to pass through the air-to-air heat exchanger and the evaporator. As the cooling requirements decrease, port B starts to open, permitting some of the air to by-pass the evaporator. A further decrease in cooling requirements closes port A and cooling is provided only by the air-to-air heat exchanger.

At this point, the Freon turbocompressor unit is shut down. Should the controls now call for heating (the airplane having reached its cruise altitude) port B starts to close and port A starts to open, bypassing some of the air around the air-to-air heat exchanger. As the demand for heating increases, port B is closed and all the air enters port C without any loss of heat of compression.

For some ground-static, low-level-flight, climb and rapid warm up cold-day conditions, more heat is required than is normally produced by the turbocompressors operating against the lower cabin pressure differentials. When this occurs, the controls cause port C to back pressure the turbocompressors to raise the heat of compression. If this is still insufficient, some of the air can be by-passed back through the turbocompressors, thereby raising the discharge temperature.

By having two separate systems, a further refinement, that of having separate controls for the passenger cabin and crew compartment, is possible. Each zone can be kept at a different temperature level to meet the desires and needs of the occupants. The cockpit thermister controls the left-hand mix valve and the main cabin thermister the right-hand mix valve.

Since the quantity of air flow required by the



DC-8 AIR CONDITIONING EQUIPMENT is organized into two systems, one of which is shown schematically here, together with its links to the other system. The cockpit thermister controls the mix valve of the left-hand system. The cabin thermister controls the mix valve of the right-hand system. Air needed for the cockpit is bled off from the left-hand system before the two systems are combined at the point the mix valves discharge to the cabin. Dual systems insure reliable air conditioning.

cabin is much greater than that of the cockpit, the necessary percentage for the cockpit is bled off from the left-hand system before the two systems are combined at the discharge of the mix valves. Dual reliability is achieved by incorporating a shut-off valve in the bleed line to the cockpit so that closing of this valve causes the air from both systems to combine before air is separated for the cockpit. Thus, if one Freon system is inoperative, this valve is closed and the hot air coming from the inoperative system mixes with the colder air from the operating system before being routed to either the cabin or cockpit. Hence, the air to both regions is cooled to the setting of the controls of the operating system.

The air conditioning system can be operated on the ground by using either engine bleed air or a ground pneumatic source to drive the cabin air and Freon vapor turbocompressors. When maximum ground cooling is required, conditioning air is furnished by the recirculation fan instead of the cabin turbocompressors. In this case, air which had been exhausted from the cabin section only is combined with approximately 12½% outside fresh air and is recirculated through the evaporator for cooling.

The control system as described is fully automatic and controlled by an electrical circuit in each system. The basic circuit consists of the main cabin (or cockpit) thermister, the outside air, and the supply duct sensing elements and the temperature control selector knob. If one or both of the automatic control circuits are inoperative, a manual over-ride is provided so that the flight engineer can, by means of cables, control the mix valve positions.

distribution system

Once the fresh air has been conditioned to the state point as determined by the control setting it is distributed to the main cabin by means of a main distribution duct located in the ceiling and running the full length of the main cabin. From this over-

DC-8

Air Conditioning System

. . . continued

head plenum, supply lines (or droppers) transfer the conditioned air at regular intervals to secondary plenum chambers at the floor line on both sides of the airplane. From these plenums the air is routed up the side wall panels and discharged into the cabin space through louvered openings at the bottom edge of the hat racks. Unlike the DC-6/7 airplanes, with intermittent air panels along the side wall, the DC-8 has a continuous side wall distribution system the full length and on both sides of the passenger cabin.

The distribution system for the cockpit posed many problems not encountered in the passenger cabin area. Large windows and structural limitations prevented the use of air-energized radiant panels to any great extent. Larger quantities of air per unit volume were required to permit the removal of the high electronic heat loads, thereby magnifying the problem of air movement control.

This is where development and simulated testing programs proved their worth. Had production proceeded with the "paper" design, the result probably would have been an unsatisfactory system for the life of the airplane.

The final configuration has two low-velocity overhead diffusers supplying 80% of the conditioned air to the cockpit area and two floor panels in the forward area at the pilot and copilot's feet supplying the remaining 20%. In addition, nine electrically heated radiant floor panels are located at the various crew stations. The cockpit air is exhausted through controlled paths for smoke evacuation purposes to an airtight radio and electronic equipment enclosure where it is used to dissipate the heat generated by the equipment. This heat is then utilized to maintain the forward cargo hold at 60 F or higher for transportation of perishable cargo.

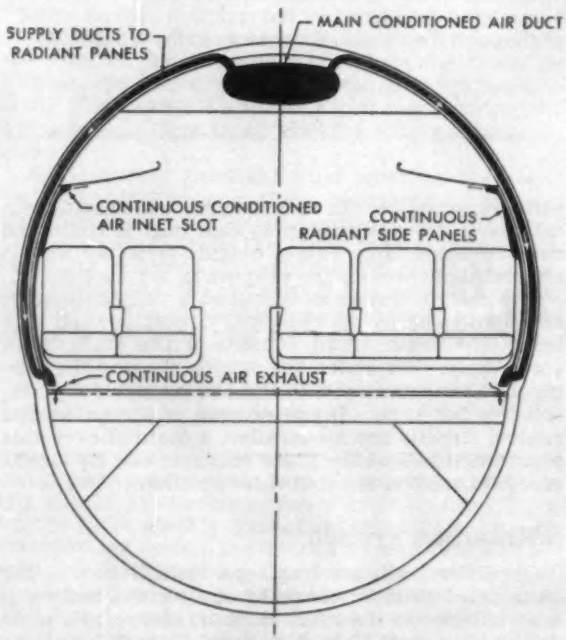
The old familiar "eyeballs" are provided at each passenger and crew location as a secondary cooling source for localized relief. It is felt that, because of the high level of comfort achieved by the design distribution system, the utilization of these "eyeballs" will be greatly reduced.

The galley and toilet areas are conditioned by drawing controlled amounts of conditioned air from the main passenger cabin through louvers in the doors and exhausting directly overboard through venturis in the outside skin of the airplane. Thus, these areas are kept at a slight negative pressure relative to the main cabin for proper odor control.

The DC-8 air conditioning system does not include a dehumidification unit. It is felt that, with a properly designed air distribution system and with an occupied space temperature between 74 and 77 F, instead of the accepted 70 to 72 F, a satisfactory level of environmental comfort can be maintained for the periods under consideration.

During high-humidity, hot-day conditions, the Freon system evaporator acts as a dehumidifier and lowers the humidity of the conditioned air.

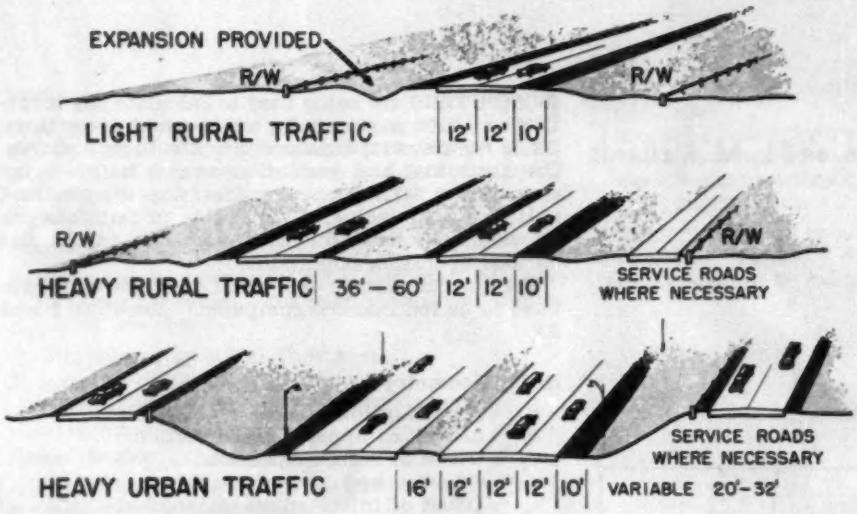
To Order Paper No. 87A . . .
. . . on which this article is based, turn to page 6.


SUPPLY DUCTS TO RADIANT PANELS
MAIN CONDITIONED AIR DUCT
CONTINUOUS CONDITIONED AIR INLET SLOT
CONTINUOUS RADIANT SIDE PANELS
CONTINUOUS AIR EXHAUST

AIR IS DISTRIBUTED to main cabin via wall ducts. A typical side wall panel used during the development program is at its minimum dimension only ⅜ in. thick overall with a ¼-in. gap for air flow. Internal baffling diffuses the air uniformly throughout the panel. The specially developed air louvers at the hat rack line introduce the air at the right velocity and in the right direction to achieve optimum diffusion throughout the occupied space. This eliminates temperature stratifications and uncomfortable drafts and provides proper scavenging of smoke and odors. The air is exhausted from the cabin through the floor at the outboard edge along the full length and on both sides of the cabin to the underfloor area and thence through the cabin pressure control valve overboard.

Gargantuan highway program . . .

. . . is getting into high gear. Interstate system boasts ultra-modern design for safe, efficient transportation.



TRAFFIC LANES, shoulders, and medians of Interstate highways are to be generously proportioned in the interest of safety. Rights-of-way and service roads control access to give freeway characteristics.

Based on paper by

D. W. Loutzenheiser
Bureau of Public Roads

AFTER 25 months of activity, the expanded highway program averages about up to schedule among the States. And Federal Aid outlays for 1958, 1959, and 1960 will triple those for the years 1954 to 1956. Some sections will be open for travel by the fall of 1959.

By 1960, when the program reaches its peak, about 442,000 men will be employed on highway construction. Moreover, the program will consume 50,000,000 tons of steel and 1,500,000,000 barrels of cement.

The interstate highways will constitute a freeway system in the sense that access will be fully controlled. Experience has shown the freeway accident rate to be one-third that of noncontrolled access highways carrying comparable traffic. Though not shown directly, the sectional views above suggest the nature of a freeway by right-of-way lines and service roads which are under control elements.

Looking ahead 20 years, the Interstate standards call for through traffic lanes 12 ft wide, with 10 ft wide right shoulders carried across all but long bridges. Medians will be at least 16 ft wide in urban areas and 36 ft or more on all rural sections. All this is shown above. Underpasses will have full shoulders on the right and 4.5 ft or more left horizontal clearance. Vertical clearance will be at least 14 ft.

With Heavy Vehicles in Mind

Gradients in general will be no steeper than 3% in flat terrain nor 5% in mountainous areas. Side slopes will be appropriately flattened and rounded. Right-of-way widths will be that necessary for all of the cross-section elements, each of appropriate dimension.

The reluctance of some State engineers to design even to minimum standards because of limited local funds and statewide highway deficiencies has been largely removed. And the Interstate highway will be built as an ultra-modern facility, with the best overall mobility, efficiency, and safety that the engineering profession can provide.

In the last analysis, the highways will resemble the new toll turnpikes except that some dimensions may be more ample and there will be many more interchanges. The interchanges will average 3 to 4 miles apart in rural areas and 1 to 2 miles in urban areas.

To Order Paper No. 66A . . .
. . . on which this article is based, turn to page 6.

Computer Determines Pay Loads for

Based on paper by

J. B. Peyrot, H. Knudsen, and L. M. Richards
Bucyrus-Erie Co.

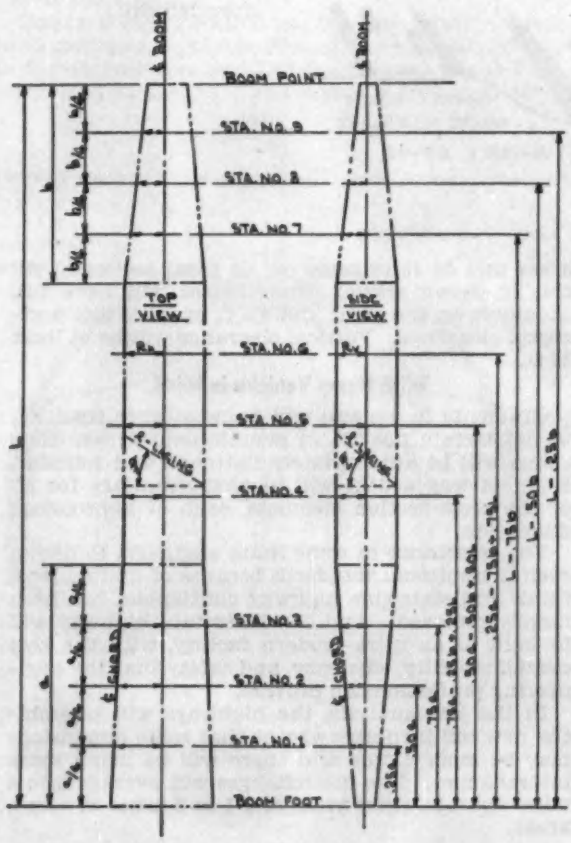


Fig. 1 — Boom stations.

COMPUTERS are being used to calculate the maximum safe pay load for cranes and excavators. Using the physical dimensions of the boom's chords, the horizontal and vertical distances between the chords, and taking into consideration the size and pattern of the lacing, it is possible to calculate the allowable pay loads for different boom lengths and various operating conditions.

For the calculation of a boom, the following data have to be fed into the computer. (See Figs. 1 and 2.)

Boom Geometry

- a = Length of lower tapered section
- b = Length of upper tapered section
- e_1 = Offset of main suspension
- e_2 = Offset of boom point sheave
- e_3 = Offset of intermediate suspension
- e_4 = Distance from suspension anchor to boom point sheave
- D_s = Pitch diameter of boom point sheave

Boom Properties

- A = Area of one chord
- e_o = Assumed boom eccentricity
- C_h = Constant for shear rigidity (horizontal)
- C_v = Constant for shear rigidity (vertical)
- c = Distance, neutral axis to extreme fiber (chords)
- R_{ho} = Radius of gyration, midsection (horizontal)
- R_{vo} = Radius of gyration, midsection (vertical)

Machine Geometry

- y = Mast is used
- o = No mast used
- o = Hoist rope off top of hoist drum
- y = Hoist rope off bottom of drum
- L_1 = Distance, boom foot to suspension terminal on A-frame or mast
- L_2 = Distance, boom foot pin to center of drum
- D_d = Pitch diameter of drum
- d_2 = Distance from center of rotation to boom foot pin
- θ_1 = Angle between L_1 and plane of revolving frame
- θ_2 = Angle between L_2 and plane of revolving frame
- H_{max} = Allowable load per hoist line

Maximum Cranes and Excavators

Computer

A code word is used for setting up a counter which determines how many boom lengths will be calculated with n different side loads and how many with m different side loads.

Stations

Stresses can be calculated for a maximum of 9 stations along the boom. For each station the following data are entered:

R_h = Radius of gyration (horizontal)
R_v = Radius of gyration (vertical)
$_2$ = Allowable stress at particular station

Boom Angles

Up to 10 boom angles can be entered expressed in degrees, minutes and seconds.
A quick loading routine enters 10 angles which are regularly calculated.
It is possible to enter given load radii for which the pay load of the boom is to be calculated. The computer then will compute the corresponding boom angles.

Side Loads

The side load applied at the boom point is expressed as a percent of the weight of the upper end of the boom and auxiliary equipment, plus the pay load. Up to five percentages can be entered. It is possible by means of the counter mentioned before to use a certain number of side loads for a group of boom lengths and all five side loads for the remaining boom lengths.

Boom Lengths

Up to 16 boom lengths can be computed.
For each boom length the following data are entered:

L = Length of boom
L_s = Length of suspension (only if mast is used)
B_1 = Weight of the upper end of the boom and auxiliary equipment
W = Weight of bare boom up to top suspension anchor
L_a = Distance from boom foot pin to intermediate suspension anchor on boom
n_1 = Number of parts in intermediate suspension divided by number of parts in main suspension
m_v = Reduction factor for Euler load due to taper (vertical)
m_h = Reduction factor for Euler load due to taper (horizontal)

If all data are to be used, a total of 199 facts must be entered. In many cases, not all of the 16 boom lengths have to be calculated, nor is it necessary to

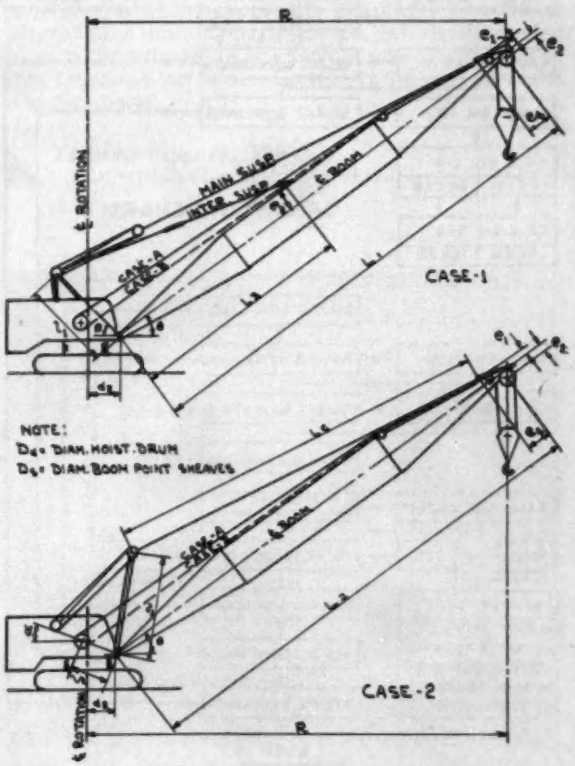


Fig. 2 — Boom dimensions and angles.

always compute the pay load for all stations or boom angles.

Once the boom program and the data are entered in the computer, the computations will start and the following results will be typed out:

1. The boom length
2. The load radius
3. A number (up to 9) identifying the critical boom station
4. The pay load
5. The suspension force.

Getting the Answers

The computer obtains these results in the following manner (Fig. 3):

The computer will first react to instructions governing suspension and hoist drum arrangements and flag the pertinent program branches to be followed in the course of the computations.

It then picks a boom length. It is normal to start out with the maximum boom length. With this length the equations 18 and 19 (Fig. 3) are calculated. These produce the Euler Load P_e in the horizontal and vertical plane.

Then a boom angle is selected. In this case, normal procedure is to start out with a zero angle, which means the boom horizontal. With this angle the load radius is calculated, to be typed out later.

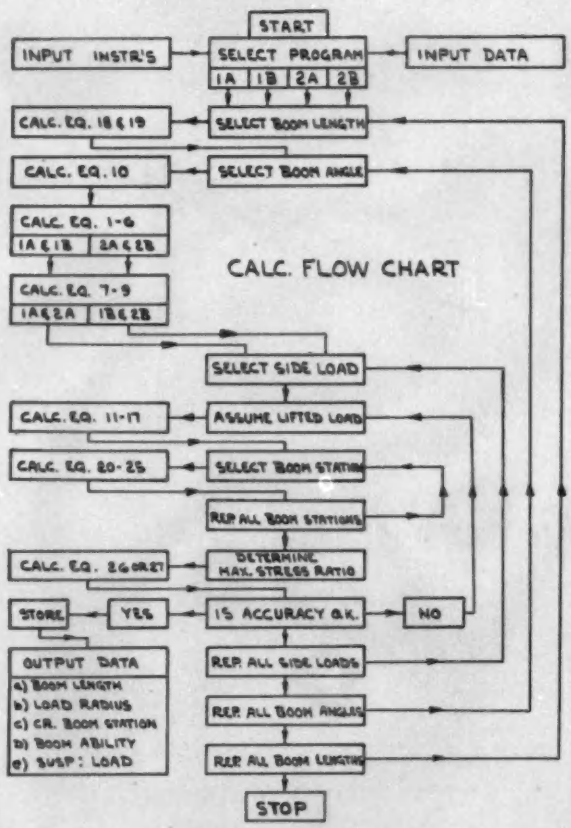


Fig. 3 — Computer calculation flow chart.

The flow diagram next shows that equations 1 to 6 are treated. This results in the following:

$_1$ = The angle between the main suspension and the center line of the boom.

r_1 = The perpendicular from the boom foot pin to the main suspension.

$_2$ = The angle between the hoist rope and the centerline of the boom.

r_2 = The perpendicular from the boom foot pin to the hoist rope.

$_3$ = The angle between the intermediate suspension and the centerline of the boom.

r_3 = The perpendicular from boom foot pin to intermediate suspension.

The computer will then select one of the side loads. In this case, it starts out with the minimum side load. It is then instructed to assume a value for the pay load.

With this pay load the required minimum number of parts in the hoist tackle is determined first. Next is the suspension force which is to be typed out later.

The important couple at the boom point is determined together with the two axial loads on the boom due to gravity and due to the imposed suspension and hoist rope forces. The last two equations in this group determine deflection due to the presence of axial compression loads.

The computer then selects one of the boom stations and starts to determine stresses. It first determines the resulting bending moments at that station (vertical and horizontal).

It takes into account the axial forces at the station and allows for manufacturing inaccuracies which could result in additional deflection of the boom. The stress determination is repeated for all 9 stations and the stresses found are compared with the prescribed maximum allowable stresses.

The assumed allowable load will only by coincidence be the correct one. Therefore, equations 26 or 27 will tell the computer how to adjust the first assumed load. This correction will be applied and the whole calculation will be repeated until the desired accuracy is obtained.

This being the case, the computer will type out the results as mentioned before and repeat the calculations for all side loads, all boom angles, and all boom lengths.

It was mentioned before that results are printed for:

up to 5 side loads
up to 10 boom angles
up to 16 boom lengths

If all are introduced, this means 800 results.

Remember, however, that each result is for the critical boom station. All 9 stations have been calculated and compared. That means 7200 calculations have been made and each is the result of a looping operation. Therefore, depending on how good the formula for the correction of the pay load is, 3 to 5 times as many calculations may actually be carried out by the computer in this process. It seems obvious that to do this work by desk calculators is impossible, because it would be prohibitive in man hours. Only when a computer is used is the complete calculation of a boom feasible.

To Order Paper No. 80A . . .
. . . on which this article is based, turn to page 6.

Hydraulic Systems . . .

. . . are on the march. Simple systems are being improved in specific details; complex systems are undergoing development to meet new needs.

Based on paper by

P. C. Mortenson
Vickers, Inc.

TRENDS in the development of hydraulic systems are toward:

1. Greater speeds, pressures, and capacities together with greater reliability for all system components.
2. Higher performance from smaller packages at reduced unit cost.
3. Increased use of the more sophisticated systems to improve vehicle performance.

Twenty years ago, pump speeds of 1200 rpm were typical of the smaller size units. Since World War II, speeds of 2000–4000 rpm have become common for small pumps, 1800–3000 rpm for intermediate size pumps, and 1500–2100 rpm for large ones. Automotive power steering pumps operating in excess of 10,000 rpm are commonplace. With this increase in rated pump speed there have come reduction in weight, less space requirement, and lower cost of installation.

Rated pressures have been on the increase. In the mobile field they have risen progressively from several hundred to 2000 psi. A limited number of piston-type pumps in the field carry ratings of 5000 psi, though their use is limited.

Increased ratings in speed and pressure have raised pump horsepower ratings appreciably. And the potential hp per lb and hp per cu in. of package might be said to represent the most striking trend in hydraulic system components for mobile equipment (Fig. 1).

Notwithstanding the depreciation of the dollar, the cost per horsepower, which is the measure of a pump's true cost, has declined. On a dollar basis, it is possible to buy 3½ times more pump today than was possible in 1940.

Power Steering Requirements

To obtain a greater amount of work per unit of time, earthmoving, materials handling, and construction machinery is now being designed to operate with very fast rates of turn. These greater turning rates impose added horsepower requirements on the hydraulic system. One way of satisfying the faster rate of turn is through a combination of increased flow and increased system pressure. Thus, the trend toward greater power steering volume requirements with substantial increase in pressure requirements is definitely here.

As mobile machinery is called upon to accomplish more work and do it in shorter periods of time, the use of multiple hydraulic circuits increases, and the central hydraulic system becomes increasingly advantageous. The aircraft industry has made notable strides in the use of central systems, but the mobile field has not adopted them as readily because a smaller number of circuits have been used per machine. However, with an increase in the number of hydraulic circuits on mobile equipment, a trend toward central system design may become established.

Hydrostatic Drive Transmissions

Hydrostatic drive transmissions, which use positive displacement pumps and motors to transmit power, to control speed, or to apply force, have not won the popularity of the hydrokinetic transmission, but they are gaining. The ease with which control is accomplished, the operational smoothness of high horsepower hydrostatic transmissions, recommend them to the entire mobile field. Operating pressures of 5000 psi and compactness in design will provide transmissions readily adaptable to vehicles where space limitations are acute. All that's needed to gain the interest of the mobile machinery field in this transmission is a reduction in its cost to make it competitive.

To Order Paper No. 78A . . .
. . . on which this article is based, turn to page 6.

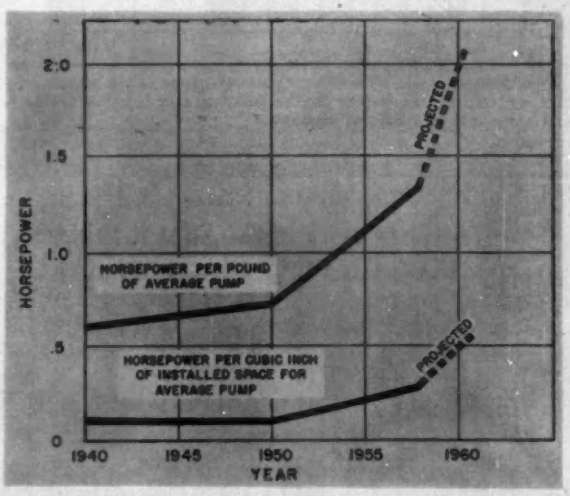


Fig. 1 — Curves showing increasing performance trends for fixed displacement pumps over the past 18 years, and projecting this trend for two years ahead.

Extra Fatigue Strength Is Now

Normal machining and finishing operations may in metals far in excess of the

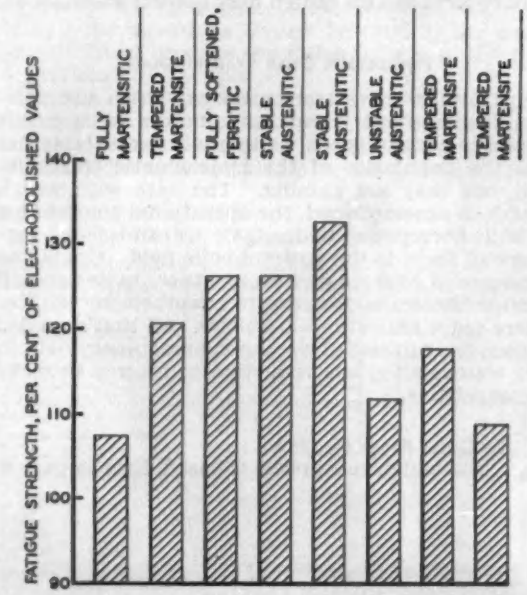


Fig. 1 — Substantial increases in fatigue strength result from mechanical polishing of steels. The effect is a combination of the smooth surface *and* the stresses set up by the polishing action. Electropolished steels are used as a basis of comparison.

The hard work of the Shotpeening and Blast Cleaning Division hasn't gone unnoticed. At the 3-day Colorado Springs meeting where Hyler's paper was presented, a Broadmoor Hotel handyman told Chairman G. F. Bush: "You guys are the hardest working bunch I've ever seen. Most conventions come here to work a little, then see the sights. All you guys do is work."

Based principally on a presentation by

W. S. Hyler,
Battelle Memorial Institute

To the SAE Iron and Steel Technical Committee's Shotpeening Division.

THREE KEY factors for good fatigue strength are cold working, residual stress, and surface finish. They occur to some extent in all processing operations. Designers have not generally made use of all these factors in their calculations.

Mechanical polishing is usually used when fatigue specimens are prepared for tests. This very polishing adds to the strength of the material, as shown in the bar graph in Fig. 1. (Electropolishing does not cold work a surface or set up residual stresses. It can therefore be used as a base line for mechanically polished specimens.)

To demonstrate further the "more-than-surface-finish" benefits of polishing, here are results of independent tests:

• Careful polishing of 18-8 stainless steel, ending with 000 emery paper, left a 0.001-in. thick layer of heavily deformed material. This was checked by X-ray technique.

• Compressive stresses in the range of 55,000–85,000 psi were detected to a depth of 0.001–0.002 in. in a mechanically polished Cr-V steel.

• Polishing N-155 alloy to 10 microin. or less produced cold working of the surface equivalent to rolling a 10–20% reduction in thickness.

Since mechanical polishing is taken as the norm for fatigue test specimens, other machining methods are compared to this technique in Table 1. The values shown, especially the last three entries, indicate that fatigue strength improves with increases in surface compressive stresses and depth of cold work. No conclusive information is available on the percentage improvement in fatigue strength due to cold working versus surface stresses.

The role of surface smoothness may not be as important in a machining operation as previously thought. Tests of lathe-turned mild steel show that work hardening and depth of hardening increase with the depth of cut. With heavy cuts, the harden-

Available

produce fatigue strengths

as-received properties

ing depth extends down to 0.020 in. Efficient metal removal (partially indicated by a low surface roughness) produces low work hardening (See Fig. 2.) This effect may more than compensate for the loss in fatigue strength usually associated with a rough surface.

An explanation lies in the mechanism of fatigue failures. Cracks may start at the surface of a part under repeated bending stresses. As the crack spreads, it reaches the compressive stress set up by one of the machining or finishing processes. The stress tends to "close" the crack and prevent it from penetrating further into the part. It may be more important in some cases to prevent a crack from spreading by having high subsurface stresses, than to retard its starting by machining a smooth surface.

Combining the effects of surface finish and subsurface stress can give better-than-either results. An example is shown in Fig. 3 where shotpeening and machine polishing teamed up to double the effect of either one individually. In this case the "craters" were removed by polishing the shotpeened specimen. Actually, the best results occurred when metal was polished off to twice the depth of the craters. The extra metal removal gave the polishing operation a chance to set up its own beneficial stresses as noted in Fig. 1.

Table 1 — Comparison of Fatigue Strength, Depth of Cold Work, and Residual Stress for Various Surface Finishing Operations

Processing Method	Fatigue Strength, % of polished surface	Depth of Cold Work, in.	Surface Compressive Stresses, ksi
Mechanical polishing	100	< 0.002	90
Electropolishing	70–90	None	None
Lathe turned	65–90	0.020	—
Milled	—	0.007	—
Ground	80–140	—	110
Surface rolled	115–190	0.040[a]	130
Shotpeened	85–155	0.020	150

[a] Higher for larger diameter shafts.

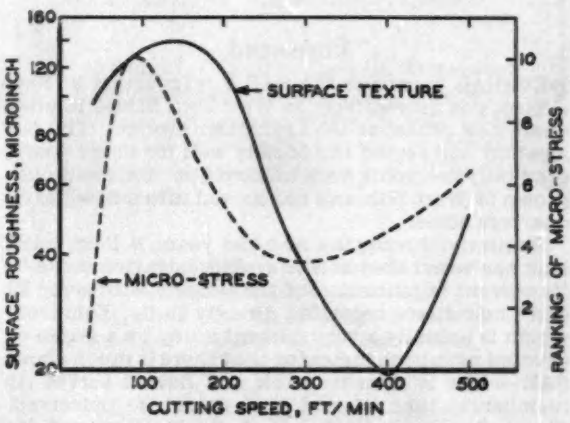


Fig. 2 — High microstresses are set up when metal is rough machined. These stresses tend to compensate for the loss of surface smoothness.

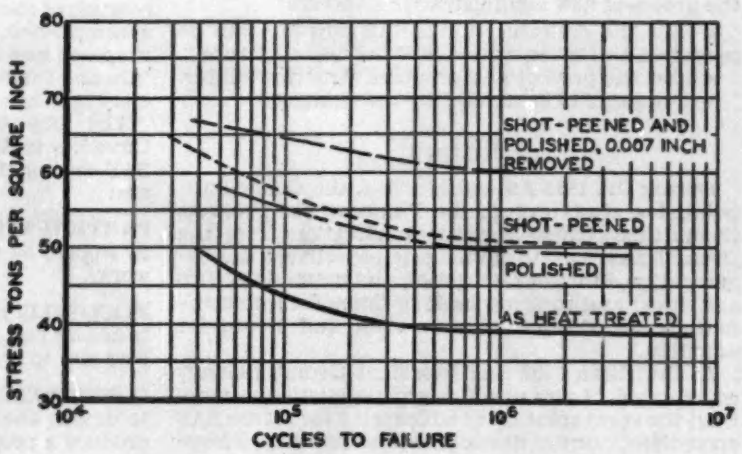


Fig. 3 — Polishing after shotpeening improves the fatigue life of a part. The best fatigue life results when more metal is polished off than is necessary to smooth the shotpeened surface.

Planning for Progress

SAE in a new administrative

by **W. F. Ford**
Information Coordinator for
SAE's Planning for Progress Committee

Foreword

SEVERAL years ago the SAE Headquarters in New York was moved from 29 West 39th Street to adequate new offices at 485 Lexington Avenue. The old location had served the Society well for many years, gradually becoming very inadequate. SAE had outgrown 29 West 39th and has moved into a new headquarters home.

Similarly, during the last two years, a long, hard look has been taken at SAE's administrative abode — its current organization of the Council with some 30 odd Committees reporting directly to it. This look, which is actually a very diligent study by a group of devoted members, indicated that there is much about SAE — how it does its work and how it serves its members — that is good and should be preserved. The look also indicated that the Society and its members could benefit, now and for years to come, by a change in its organizational structure.

The subject of this presentation is a discussion of the proposed new administrative structure:

- How the desirable things SAE now has can be preserved and incorporated into the new structure.
- How the present and proposed structures differ.
- The gains to be derived by the change.

History

During the 1956 Annual Meeting, the Council appointed a study group, the Planning for Progress Committee. This Committee's direction from the Council was ". . . to investigate objectively the organization, functions, purposes, and methods of SAE activities; and to bring back to Council recommendations for Council consideration and hoped-for adoption."

At that time, 1956 SAE President George Delaney commented, "I visualize this group's mission as more than the mere creation of a blueprint for future SAE operations. In the development of its study, I hope it will establish a new climate, fresh attitudes and points of view among members and member groups attuned to the look ahead. Evolved in this spirit, the plans for progress, when eventually made ready for use, will fit comfortably like an old shoe."

Thus, a task had been assigned —

1. To look at the Society's structure as it has been for some 30 years.
2. To pick out the desirable practices, philosophies, policies, and traditions which SAE now has and to establish means for preserving them.
3. To plan for the future by proposing changes:
   a. In the Society's present structure.
   b. In its methods of accomplishing the Constitutional objective.
   c. To create means for best equipping SAE to adapt itself to the changing and growing needs of automotive engineers.

The result is to insure that SAE —

- Will have a better future
- Can grow in scope as well as size
- Can more readily develop the programs and benefits inherent in the Society's activity

Present Status

Much of the assignment from the Council has been accomplished. The Committee has developed a proposed new structure which it believes will maintain and further improve all the good things the Society now has.

The proposed structure is designed to enhance three key features that have proved so important to SAE during the past half-century. These features are:

PARTICIPATION:
to engage as many members as possible in Society work.

FLEXIBILITY:
to absorb new and changing technical needs of members and to produce services to fulfill those needs.

CONTINUITY:
to design the Society's administrative structure to produce a proper blending of knowledgeable men —

home

experienced in handling and leading SAE affairs — with new men who have demonstrated aptitudes.

The Committee believes the enhancement of these three features will continue the Society's chief Constitutional objective:

Development, Collection, and Dissemination of Technical Information

The Planning for Progress Committee has not desired hasty action toward changing the present structure, which has served the Society well. The Committee felt it must be *SURE* that any new plan would provide more effectively for future needs of SAE.

Presentations and discussions of its ideas have been held with many members, notably ones active in various Society affairs. Reception has ranged from enthusiastic recognition of the potential gains to little response. Generally, the latter occurred among members presently not well informed of how SAE is organized and operates. Many have commented that several of the specific and detail plans could and should be incorporated expeditiously.

The Planning for Progress Committee feels it now has a proposal that is ready for Council consideration. Hence, this report is submitted.

Proposed Structure

1. Representing all of the Society and managing its affairs —

The Board of Directors

— replacing the present Council.

2. Reporting to, operating under the Board of Directors, and appointed by the President with approval of the Board of Directors —

Engineering Activity Board —

a. To develop technical information for *Members*

b. To direct *National Meetings*

Technical Board —

To continue its present function of developing technical information for Industry

Sections Board —

To guide and lead activities in Sections, Groups, and Student Branches

continued on next page

Planning For Progress got its official start toward consideration by the Society's entire membership, when SAE Council spent a full day on Sept. 7 in discussion of its potentials.

Meeting in Chicago, with the entire Planning for Progress Committee on hand to answer questions, Council discussed the effect of the proposals on its own future functions, on those of existing Activity Committees, and on the work of the Sections and each of the Society's numerous administrative committees.

Following a full discussion, Council approved the proposals for changes in the Society's organization suggested by the Planning for Progress Committee and also the Constitutional amendments required to implement the proposals.

As a result of Council's approval, the proposals will be submitted to SAE's voting members — with Council's recommendation for their acceptance — full details of the proposed amendments to the Constitution will appear in the November SAE Journal.

Before the Society's next Business Session (at Detroit in January), similar discussions of the proposals will have taken place at meetings of each of SAE's twelve Activity Committees.

Then, at the Business Session in January, the proposed amendments will be presented for discussion and final amendment prior to going to the membership for mail ballot.

Most important and interesting single information-piece presented to Council as a basis for its Chicago discussion was W. F. Ford's:

"Planning for Progress —

SAE in a New Administrative Home"

— which is presented here in full.

SAE

■ in a new administrative home

. . . continued

The Board of Directors

This highest administrative body of SAE would consist of:

President Treasurer 2 Past-Presidents 12 Directors	Nominated by the Annual Nominating Committee

9 Directors — Nominated by the three Boards

25 Members of Board of Directors

This Board of Directors for the Society is visualized much like the directors of business corporations — representative of all of the organization, not one segment of it as some Vice-Presidents may feel they are now obligated to be.

1. Continuity

The 21 Directors would be elected to three-year terms with the terms of one-third expiring each year. The President would continue to be elected for one year and could not be re-elected. The Treasurer would also continue to be elected for one year and, as now, could be re-elected. The two surviving Past-Presidents who last held office would continue to serve as they now do.

The proposed Board of Directors would in any one year have 16 members from the previous year to serve with nine new members, provided the Treasurer is re-elected and assuming the new President was a Director during the previous year. The present 22-member Council may have seven members from the previous year — two Past-Presidents, three second-year Councilors, the Treasurer (if he is re-elected), and the President (who has not always previously served). There usually are 15 new Councilors each year, the 12 Vice-Presidents, and the three new Councilors. Thus, where there are now seven experienced Councilors and 15 new ones, there would be 16 experienced Directors and nine new ones. The proportionate change in continuity should provide considerable potential benefit to the Society. It appears highly desirable for the future of SAE.

The three-year term for a Director also appears highly desirable to the member serving in that capacity. The present one-year term for Vice-President, many have commented, is too short for adequate familiarization with Council operations and for most effective service. The three-year Director's term should provide ample time to become well-informed. Without the indoctrination each year, the Director should be much more effective to the Society. Personally, he should derive more satisfaction from his ability to contribute more effectively.

2. Flexibility

The longer terms and their representation for all of SAE should cause the Board of Directors to be more effective in serving as the Society's top governing body. Increased knowledge of SAE background and policies and the longer experience should aid Directors in developing specific knowledge in all phases of Society activities. They can be more expert in establishing and defining broad policies. SAE can benefit largely from this in the areas of information development for members, technical committee work for Industry, and Section and Member affairs.

To the individual Director, his increased scope and greater contribution can impart as much prestige as now accompanies a vice-presidency.

With the three boards that will report to the Board of Directors, there will be mechanisms to permit doing a *better* job in existing fields as well as entering appropriate new fields. Committees can be readily established to absorb the new and changing technical needs of members. These committees will produce the services to fullfill the needs where they are appropriate to automotive engineers.

3. Participation

Having three more members of the Board of Directors than there now are members of the Council may not be significant in increased member participation in Society work. Under the proposed new structure, however, the influence of the Board of Directors on increased member participation in all areas of SAE can be quite large.

With the three Boards and the Standing Committees having authority to create and to disband committees, as the Technical Board now does, and having the mechanisms to enter appropriate new technical and administrative fields, the Board of Directors can encourage much greater participation.

4. Enhanced Key Features

The Board of Directors, it would appear, would be in excellent position to encourage growth and improvement in the areas of participation, flexibility, and continuity in the Society.

Officer Nominations

1. Annual Nominating Committee

This most democratic Committee would be continued with little modification. The proposed Annual Nominating Committee would be composed of 45 members, compared with the present 42. The Committee would consist of:

a. One delegate from each Section (39 at present)
b. Three delegates-at-large from Past-Presidents' Advisory Committee
c. One delegate each from Engineering Activity Board, Technical Board, and Sections Board

The extent of change is the replacement of the three delegates-at-large elected at the Annual Business Meeting by the three delegates-at-large from the Past-Presidents' Advisory Committee and the addition of the three delegates from the three operating boards.

The Annual Nominating Committee would continue to be composed of members having broad

knowledge and personal experience with all phases of the Society's operation.

Convening during the Annual Meeting, the Annual Nominating Committee would nominate:

President — one-year term
Treasurer — one-year term
4 Directors — three-year term

2. Nominating Committees of Operating Boards

In accordance with each Board's Rules and Regulations, the Engineering Activity Board, the Technical Board, and the Sections Board would each establish a Nominating Committee. Each Board's Nominating Committee would nominate one Director each year.

3. Nominees

Each year, two-thirds of the nominees (6) would be nominated by the Annual Nominating Committee. One-third of the nominees (3) would be nominated by the three Boards' Nominating Committees.

In comparison, there presently are 17 nominees each year. The Annual Nominating Committee establishes only five of them — nominees for President, for Treasurer, and for three Councilors. The other 12, the Vice-Presidents, are nominated by Activity Nominating Committees.

Election

The proposed Annual Ballot would be for nine offices — the President, the Treasurer, and seven Directors.

The current election procedures would be continued: namely, that each voting member of the Society would receive a ballot listing the nominees and offices on which he registers his vote.

The Three Operating Boards

- **Technical Board**
- **Engineering Activity Board**
- **Sections Board**

1. How Did They Originate?

These three boards were evolved from the apparent inflexibility of the Society's present structure, particularly in the Professional Activity area. SAE members were becoming interested in, and were beginning to work in, many new fields of automotive engineering not fully encompassed by the 12 Professional Activities. There seemed to be no place in the existing structure to adequately serve the technical information needs of some Society members. This has been particularly so for those members working in such areas as utility engines, nuclear energy, guided missiles, computers, and construction and industrial machinery.

This need for Flexibility to replace the inflexibility was aptly observed by Past-President Rosen. At the inception of the Planning for Progress project, he said, "What we need in SAE are rubber pigeon holes rather than cast iron ones. We need rubber ones to assimilate our rapidly changing technology."

In casting about for these "rubber pigeon holes," the Planning for Progress Committee noted the flexibility of the SAE Technical Board and the operations of its Committees. The Technical Board has been successfully serving the technical needs of Industry, with ample flexibility to meet changing conditions. Why could not a similar board meet the changing and expanding technical needs for members in the areas of Professional Activities?

The Technical Board's current authority —

To create committees as needs arise
and
To disband these committees once
there is no longer any need

— appeared to be an excellent pattern.

The Technical Board, as it exists and operates today, is already established and functioning in a manner in keeping with the three key features — flexibility, participation, and continuity. Additionally, in its scope the Technical Board has much Council-assigned autonomy. In this area, the administrative functions of the Society are also well decentralized by and from the Council. This is a desirable feature in any proposed structure that is designed for growth in both scope and size.

2. Three Operating Arms for Directors

Quite logically, with the Technical Board already organized to fulfill the Society's future needs in technical information for *Industry*, similar boards could satisfy the future needs for *Members* and for *local SAE units*.

Thus, the main work of SAE could be administered by the Board of Directors but actually be conducted by the three operating boards and their committees.

The **Technical Board** would continue its function of —

Providing Services to *Industry* and *Government* in Developing *Standards* and *Recommended Practices*

The **Engineering Activity Board** could assume the work of the 12 Professional Activity Committees, the several Special Advisory Committees, and the Meetings Committee. This Board's responsibilities would be:

a. The development, collection, and distribution of technical information to *Members*
b. The responsibility for *National Meetings*

The **Sections Board** would assume the work of the Sections Committee and the Student Committee. This Board's function would be to serve members at Section, Group, and Student Branch levels. Its responsibilities would be:

a. To further the organization and work of *Sections*, *Groups*, and *Student Branches*
b. To enhance the *value of membership* by extension of SAE's technical and other services through the Society's local units.

continued on next page

SAE ■ in a new administrative home

. . . continued

3. Operating Board Membership

Each board would be composed of not more than 24 members, each serving three-year terms. To provide continuity and participation, one-third of the members would complete their terms each year.

Operating Board members would be appointed by the President, with approval of the Board of Directors.

A Board Chairman, from the Board membership, would be appointed to a one-year term by the President, with approval of the Board of Directors.

4. Rules and Regulations for Operating Boards

Probably one of the first actions of each board would be the development of its rules and regulations. The current set of Technical Board Rules and Regulations could be used as a model. Once developed, each board would submit its rules and regulations for approval by the Board of Directors.

Proposed rules and regulations for the Engineering Activity Board and the Sections Board have been developed by the Planning for Progress Committee. Uniform in their format, these proposals have been reviewed by special groups of members experienced in the proposed operating areas of these two boards. Once the original membership of the two boards is established, the proposed rules and regulations would be submitted to them for their final formulation and submission to the Board of Directors.

5. Authorities of the Three Operating Boards

These boards would be authorized by the Board of Directors as:

a. Advisory groups to the Board of Directors on policy matters in their respective areas

b. Operating arms of the Board of Directors, empowered in their respective areas as may be delegated by the Board of Directors

6. Responsibilities of Members

Members of the operating boards, and committees under their jurisdictions, would function independently *as individual SAE members*, not as representatives of geographical areas or Society technical activities.

Potential Benefits from Proposed Structure

The Society's administrative affairs in three large and specific areas would be decentralized to the three operating boards. Administration would be under surveillance of and responsible to the Board of Directors. This decentralized arrangement seems quite desirable in many facets of SAE's present operations and in the Society's future. Some of the potential benefits are:

1. Creates sound administrative cognizance of the Society's three main operating areas —

Information Development
Technical Committee Work
Local Member Units

2. Provides greater opportunities for average member to participate in and have voice in Society operations through:

a. Mechanisms for effective committee creation and action — when need has been established and judged appropriate for SAE to fulfill.
b. Well defined channels for submission of suggestions, comments, and ideas from individual members and member groups.

3. Preserves the practices, philosophies, policies, and traditions that have contributed so much to the Society's half-century of growth and member benefit.

4. Expands *existing* methods of operation and member participation already proven by the Technical Board.

5. Provides formal and planned means for assimilating the expediencies taken by Council from time to time when it has set up special advisory committees in new technical areas.

6. Permits development of and utilization of specialized and expert talents in the areas of member technical information and local units, as has been accomplished so successfully in the Technical Board's area.

7. Places complete responsibility for planning and conducting National Meetings in one informed working body. Presently only the Council itself is sufficiently so empowered.

8. Establishes means for effective liaison and coordination of similar or related member interests, particularly between the Engineering Activity Board and the Sections Board for member technical information.

9. Does not eliminate any existing groups, including Professional Activity Committees, but realigns them for more effective over-all Society operations.

10. Provides a format for SAE's future, just as effective in 20 years when the membership may be 50,000.

Putting New Structure in Operation

Council acceptance and approval are the initial requirements. The proposed organization structure and the necessary amendments to the Constitution, incorporating the basic proposal, would be submitted to the Council by the Planning for Progress Committee.

Should Council approve the Committee's recommendations, Planning for Progress must then be submitted to the members. In the form of amendments to the Constitution, the favorable vote of the members is required.

A probable timetable would have two phases. The first step, from Council approval of the Committee recommendations to completion of member vote on the Constitutional amendments would require several months. In the second phase, about a year and a half would be required for the Society to start operating fully under the new structure.

Radical Changes

. . slated for truck tires. Higher road speeds forcing use of new construction and materials to improve performance and keep costs down.

Based on paper by

T. A. Robertson, The Firestone Tire & Rubber Co.

THE truck tire of the future will very likely have skinned-down racing type construction, make use of the latest in synthetics, have a greater number of plies and higher inflation pressures, and be tubeless. These changes will come about because of increases in truck horsepower and higher operating speeds.

Dissipation of heat generated by uninterrupted, high-speed, turnpike travel can be accomplished by going part way in the direction of thinner treads and offsetting the reduction in material by using more durable tread compounds or resorting to more frequent retreading. Portable equipment which will retread a tire without removal from the rim is a distinct possibility.

Advances in synthetics, exampled by coral rubber which surpasses natural rubber, suggest the possibility of tailoring tires with chemically produced materials. We can imagine a tire with synthetic tread having vastly improved abrasion and cracking resistance, its body made of rubber designed especially to provide low running temperature and maximum adhesion and resistance to separation and aging, while the tubeless interliner will be made of another synthetic impermeable to air and with a plasticity capable of sealing punctures.

Cord Becomes Stronger

Cord, next in importance to rubber, is undergoing strenuous development and the outlook is bright. Now available are new experimental 1100/2 denier super super rayons with strength increased from 18 to 24 psi, and new nylons with 31-psi tensile in an 840/2 denier cord. Steelcord has already made its mark in bus tires. Last year a new construction was introduced which is comparable in weight to a fabric tire and can be operated at a similar inflation pressure. Steelcord construction offers such advantages as: blowout resistance, cooler running, resistance to cuts and punctures, no service growth, better tread wear, and more retreads.

In a still more recent construction, the body is composed of a single ply of wire running straight across the tire from bead to bead in contrast to the criss-cross angle normal in the conventional tire. Stability is obtained through a layer of steel tread plies running at a very high angle in the crown of the tire. This produces in effect an inextensible flexible steel band running circumferentially around the tire and it is this characteristic which gives better tread wear since it practically eliminates scuffing of the tread. Fig. 1 shows the deflection under load of the conventional tire and the special steelcord tire. The zero cord angle construction provides greater deflection as well as a longer contact area.

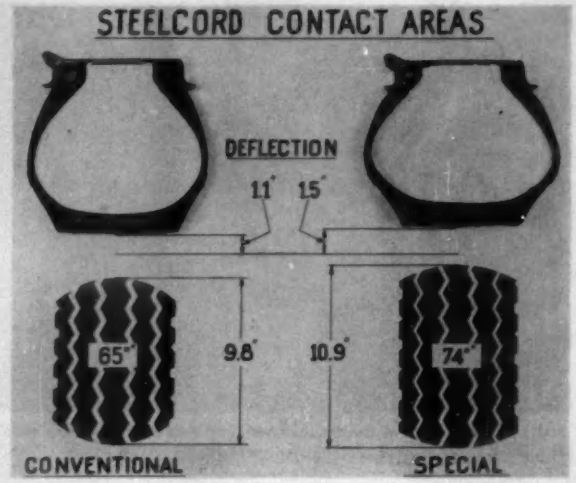


Fig. 1 — Zero cord angle construction of new steelcord tire provides greater deflection and a longer contact area for better wear and traction.

Rim development can be expected to bring about a better strength-to-weight ratio, and greater resistance to fatigue and corrosion. The one-piece, drop-center tubeless truck tire is a major step in the direction of simplicity. The next step may be to manufacture the rim and wheel disc in one piece and ultimately the complete tire and wheel may come from the factory as a preassembled unit approaching perfection in runout and balance.

High Inflation Pressures On Way

The cramming of more tire load capacity into less space can be accomplished by going to higher inflation pressures with a greater number of plies. This makes for a harder ride, but in turn can be handled by air spring suspensions, which already have proved out on buses. Air spring suspension makes possible increased cargo capacity, reduction in weight, better ride, and lower vehicle maintenance. And it reduces the bounce of empty or lightly loaded trailers to minimize the scuffing and wiping of tire treads.

Another possibility is the low-profile type of design now used on earthmoving equipment. It could be used on highway truck tires, particularly to carry high front-axle loadings without resorting to excessively large diameter tires which create vehicle design problems.

We predict steady improvement in tubeless tire performance through design features and chemical compounding. We can look for simplified airtight repairs for punctures and injuries, and for techniques making it easier to detect nails and foreign objects before damage is done. Valves located in the sidewall of the tire can be anticipated. This would simplify inflation and reduce the space required between rim and brake drum.

To Order Paper No. 69B . . .
. . . on which this article is based, turn to page 6.

Fig. 1 — Appearance of three specimens (Fe-Cr-Al alloy, left; 430 stainless, center; and 316 stainless, right) after exposure for a week to still air at 1850 F.

Chromium Gives Stainless Properties to

Based on paper by

B. King, J. J. Mueller, N. N. Ida, and F. G. Tate

The Martin Co.

IRON-ALUMINUM base alloys normally exhibit high oxidation resistance. Adding chromium to the aluminum appears to impart room-temperature corrosion resistance to iron much like that of adding chromium alone.

Iron-aluminum base alloys tend to be deficient in room-temperature ductility, in weldability, in high-temperature strength, and in their susceptibility to work-hardening. However, their qualities can be improved by means of alloying additions and through refinement of preparation and heat-treating methods. They then compare favorably in strength and ductility at both high and low temperatures with the ferritic stainless steels.

The most striking characteristic of Fe-Al base alloys is their resistance to high-temperature oxidation, which can be made to exceed that of any stainless steel. Fig. 1 shows the appearance of a 5.5 Al, 9.5 Cr, balance Fe base alloy, a ferritic stainless steel, and an austenitic stainless steel after exposure for a week to still air at 1850 F. Note how well the Fe-Cr-Al alloy stands up under these conditions.

Aluminum alone doesn't appear to be as effective as chromium in inhibiting room-temperature corrosion. But a combination aluminum-chromium addition appears to be nearly as influential as straight chromium in this respect. Fig. 2 shows the Fe-Cr-Al alloy and type 430 stainless steel after being subjected to a salt-spray test.

Problems in Fe-Al Alloy Development

The use of binary Fe-Al alloys has been limited by their room-temperature brittleness. Some feel that the following factors are responsible:

1. The appreciable difference between the ion diameters and crystal structures of iron and aluminum.
2. The tendency of an Fe_3Al-type ordered structure to be born in alloys containing 13–21% aluminum.
3. An apparent sensitivity of these materials to the effects of interstitially-dissolved elements.
4. A considerable bent for grain growth at high temperatures.

A second inherent deficiency of binary Fe-Al alloys is their moderate high-temperature strength. Aluminum additions tend to prevent allotropic transformation in iron, and Fe-Al base alloys retain a body-centered structure at all temperatures.

The inclination to grain growth make the Fe-Al alloys hard to weld. The weld zone is usually a coarse, columnar structure when Fe-Al filler metal is used. Using an austentic filler metal results in a

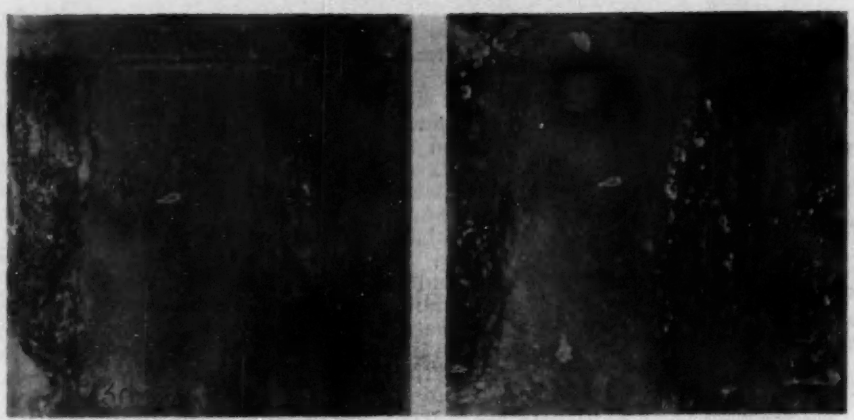
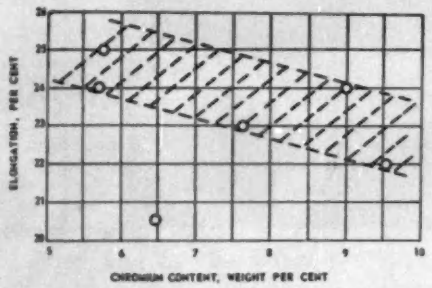
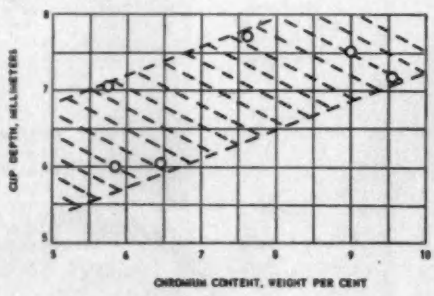


Fig. 2 — Appearance of specimens after salt-spray test; 672-hr exposure to 20% NaCl solution at 95 F. At the left AISI Type 430 Stainless Steel (14-18 Cr), weigh loss: 1.58 mg/cm²-mo. At the right Fe-Cr-Al experimental alloy (5.5 Al, 9.5 Cr, 0.5 Ti, 0.035C), weight loss: 1.97 mg/cm²-mo.

Iron—Aluminun Alloys



LEFT - TENSILE TEST ELONGATION AS A FUNCTION OF CHROMIUM CONTENT.



RIGHT - ERICHSEN TEST CUP DEPTH AS A FUNCTION OF CHROMIUM CONTENT

Fig. 3 — Effect of chromium content on ductility of 4.14 to 5.85 Al, Fe-Al alloys. Although there is a tendency for chromium to reduce tensile ductility, chromium additions appear to enhance the deep-drawing capability of these alloys.

Chromium Gives Stainless Properties To Iron–Aluminum Alloys

. . . continued

ductile deposit, but the heat-affected zone next to the weld becomes brittle.

Improving Fe-Al Alloy Properties

Martin rectifies the undesirable properties of the Fe-Al alloys by adding a sizeable amount of chromium. This eliminates the superlattice as a source of difficulty. In adition, chromium contributes corrosion resistance.

Small quantities of other elements are also added to impart specific characteristics to the alloys. Titanium, silicon, tantalum, molybdenum, and beryllium are thought to promote high-temperature strength and good creep properties. Titanium, tantalum, and niobium (columbium) tend to improve room-temperature ductility. Zirconium additions have been found to have a beneficial effect on the way in which certain alloys respond to heat treatment.

Vacuum melting of the Fe-Al alloys provides control of the compositions and prevents atmospheric contamination.

Properties of Experimental Alloys

Martin has developed two experimental alloys. The first of these, the 5.5 Al, 9.5 Cr, balance Fe base material, appears to have properties comparable to those of type 430 stainless steel. The salt-spray corrosion resistance of this alloy is shown in Fig. 2. Its mechanical characteristics are compared with 430 stainless in Table 1. Note that the Fe base alloy shows a decided tendency to work-harden.

Chromium additions have an interesting effect on the ductility of low-aluminum alloys of this type (Fig. 3). There is a tendency for chromium to reduce tensile ductility. However, chromium additions seem to enhance the deep-drawing capability of these alloys.

The second experimental alloy contains 7.5 Al, 5 Cr, and small additions of other elements in an ingot-iron base. No deliberate attempt was made to impart good high-temperature properties to this alloy as the primary concern was ductility. Its mechanical properties, together with those of some competing alloys, are listed in Table 2; all the data apply to annealed material.

The exceptional oxidation resistance of this alloy is compared with that of AISI type 347 stainless steel in Fig. 4.

Neither of the experimental alloys can be successfully fusion-welded. Fig. 5 shows a transverse section through a weld showing the coarse, brittle structure that results when the metal is melted and solidified. Resistance welds, particularly those made without producing a molten nugget are, however, strong and ductile. Fig. 5 also shows such a weld.

High-temperature strength can be developed by means other than solid-solution effects. Martin is considering two possibilities: the formation of precipitated phases that are stable at high temperatures, and the admixture of a finely divided insoluble refractory.

Success has been achieved in hot-roll bonding the

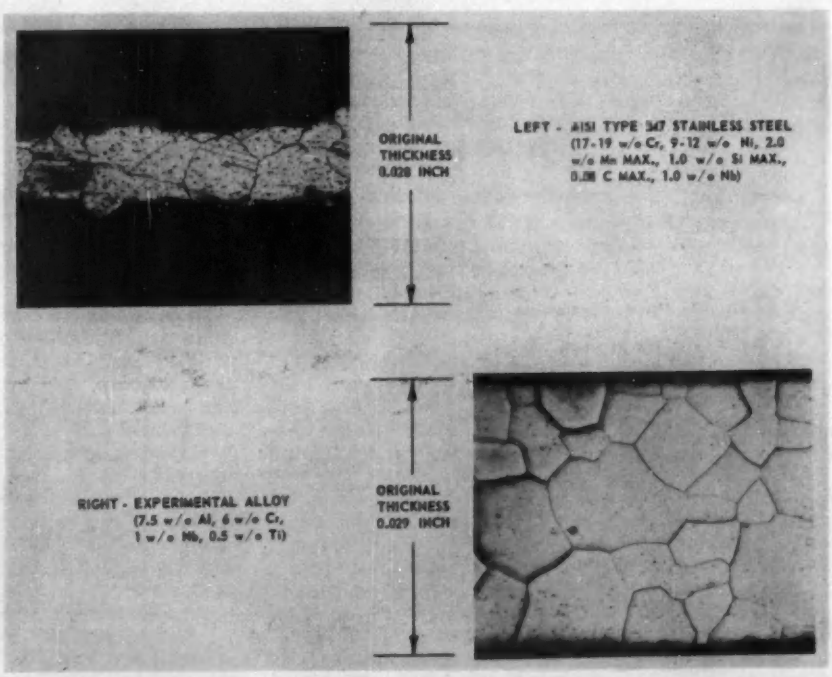

ORIGINAL THICKNESS 0.028 INCH
LEFT - AISI TYPE 347 STAINLESS STEEL (17-19 w/o Cr, 9-12 w/o Ni, 2.0 w/o Mn MAX., 1.0 w/o Si MAX., 0.08 C MAX., 1.0 w/o Nb)
RIGHT - EXPERIMENTAL ALLOY (7.5 w/o Al, 6 w/o Cr, 1 w/o Nb, 0.5 w/o Ti)
ORIGINAL THICKNESS 0.029 INCH

Fig. 4 — Photomicrographs of sections through specimens exposed to still air at 2000 F for 400 hr. 100 ×. The experimental alloy shows excellent oxidation resistance under these conditions.

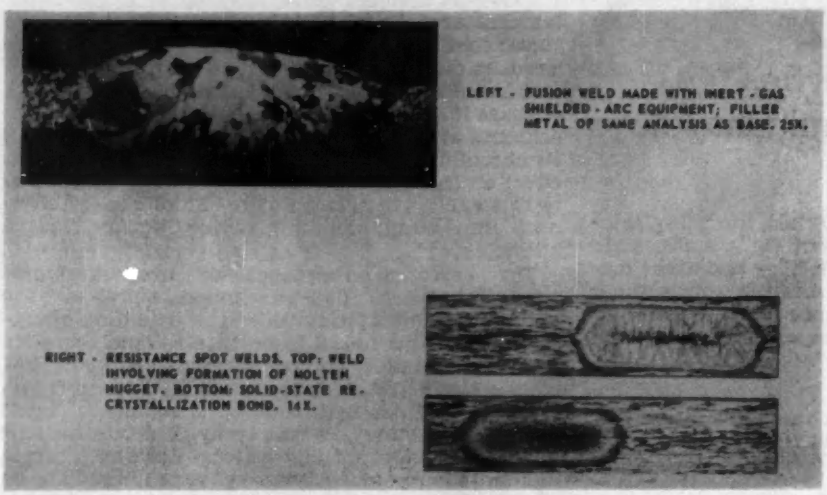

LEFT - FUSION WELD MADE WITH INERT-GAS SHIELDED-ARC EQUIPMENT; FILLER METAL OF SAME ANALYSIS AS BASE. 25X.
RIGHT - RESISTANCE SPOT WELDS. TOP: WELD INVOLVING FORMATION OF MOLTEN NUGGET. BOTTOM: SOLID-STATE RE-CRYSTALLIZATION BOND. 14X.

Fig. 5 — Fusion welding the experimental alloys results in a coarse, brittle structure. Resistance welds are, however, strong and ductile.

Table1 — Properties of a 5.5 Al, 9.5 Cr, Balance Fe Base Alloy Compared with AISI Type 430 Stainless Steel

	Experimental Alloy[a]	AISI Type 430
Yield Strength (0.2% offset), psi		
annealed material	64,000	35,000 min[b]
30% cold worked material	108,400	—
Ultimate Tensile Strength, psi		
annealed material	82,900	70,000 min[b]
30% cold worked material	109,450	—
Elongation, % in 2 in.		
annealed material	22.0	20 min[b]
30% cold worked material	4.0	—
Erichsen Cup Depth, mm (annealed material)	7.2	7-9[c]
Minimum Bend Radius (annealed material)	½ T	½ T[b]

[a] Martin Co. test data, 0.030-0.040 in. sheet.
[b] ASTM A 176-54.
[c] AISI Steel Products Manual.

Table 2 — Properties of a 7.5 Al, 5 Cr, 1 Nb, ½ Ti, Balance Fe Alloy, and Certain Other Materials

	Experimental Alloy (sheet stock specimens)[a]	Type 446 Stainless (wrought bar specimens)	Type 316 Stainless (wrought bar specimens)	Thermenol 16 Al, 3.3 Mo, (sheet stock specimens)
Room Temperature Properties:				
Yield Strength (0.2% offset), psi	60,000	51,500[c]	38,500[c]	—
Ultimate Tensile Strength, psi	87,500	83,000[c]	85,500[c]	129,000
Elongation, % in 2 in.	24	25	60[c]	10.5
Properties at 1500 F:				
Yield Strength (0.2% offset), psi	5000	3500[c]	18,500[c]	—
Ultimate Tensile Strength, psi	11,000	8000[c]	27,500[c]	23,000
Stress to Produce Rupture in 1000 hr at 1500 F.	1000	1100[b]	7000[b]	1000[a]

[a] Martin Co. test data.
[b] Metals Handbook, 1948.
[c] United States Steel Corp. Publication ADV-18566 (S).

Chromium Gives Stainless Properties To Iron–Aluminum Alloys

. . . continued

7.5 Al, 5 Cr alloy to other materials, including some of the high-hot-strength alloys. Fig. 6 shows bond interfaces between an Fe-Cr-Al alloy and other materials. Composite materials made in this manner combine the oxidation resistance of an aluminum-bearing clad with the high-temperature strength of the base material.

To Order Paper No. 60B . . .
. . . on which this article is based, turn to page 6.

Based on discussion by

E. D. Marande, V. F. Zackay, and G. H. Seaver
Ford Motor Co.

Considerable research and development work has been done at the Scientific Laboratory, Ford Motor Co., on the properties of iron-aluminum alloys; both the binary system and more complex alloys based on the binary iron-aluminum system have been investigated.

Our work on the oxidation of both iron-aluminum and iron-aluminum-chromium alloys at elevated temperatures (in the range from 2000 to 2200 F) shows that the oxidation resistance is primarily dependent on the aluminum content. The effect of chromium at levels below about 7–8% (by weight) appears to be negligible, while at higher aluminum contents and still higher temperatures (above 2200 F) chromium appears actually to have a deleterious effect on the oxidation resistance of the alloy. Due to this effect, it might be more suitable to use a binary iron-aluminum for cladding higher-strength alloys.

The corrosion resistance of iron-aluminum-chromium alloys depends much more on the chromium content than does the oxidation resistance. This was found to be true for the corrosive media employed in our laboratory, which were 40% boiling nitric acid, 10% acetic acid, 1% ferric chloride, 20% sodium hydroxide, 10% sodium chloride (immersed testing) 5% salt spray, and intermittent immersion in Detroit city water. However, chromium and aluminum were not necessarily found to be additive in conferring corrosion resistance; for example, a combined chromium and aluminum content of 15% (8%Al and 7% Cr) was not nearly as corrosion resistant as type 430 stainless (14–18% Cr) in 40% boiling nitric acid.

For the past several years, considerable welding research has been conducted on iron-aluminum alloys by the Manufacturing Research Group of our Company and successful fusion welding techniques have been developed for alloys containing up to 8% aluminum. It is possible that these techniques or a slight modification of them might prove applicable to the authors' iron-aluminum-chromium alloys.

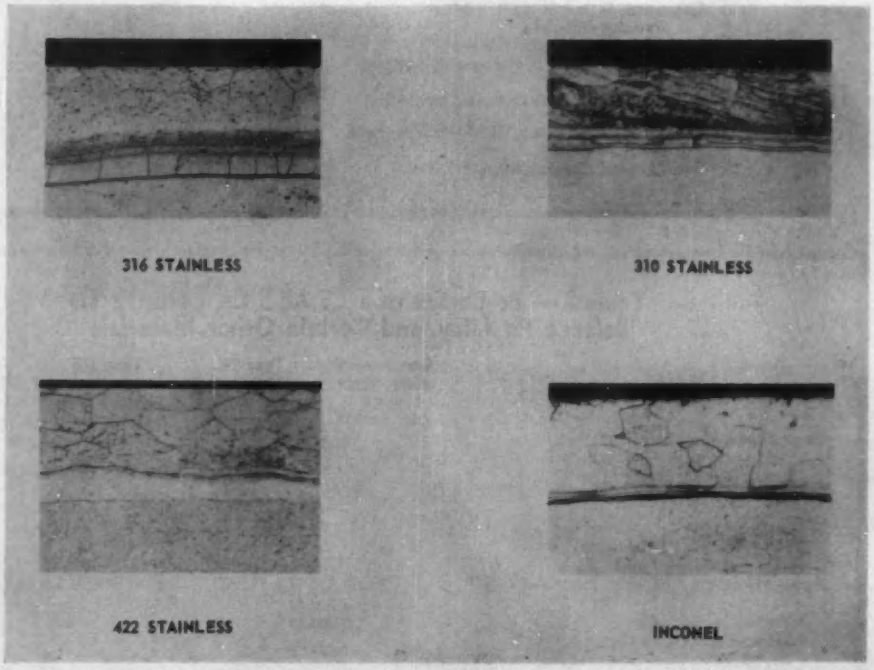


Fig. 6 — Photomicrographs showing appearance of bonds between experimental alloy (7.5 Al, 5 Cr, 1 Nb, 0.5 Ti, balance Fe) and various high-hot-strength materials. 100×.

Diesel Promising for Future; Gas Turbine Slated for Larger Sizes

Based on paper by

Peter Kyropoulos
General Motors Styling Staff

THE DIESEL ENGINE remains promising for future applications. The gas turbine is here in a competitive form and shows great promise in the size range beyond (larger than) the diesel engine.

Changes in the diesel engine have been relatively slow and gains small. This doesn't mean, however, that we have reached the end of the line as far as progress is concerned.

For comparison and forecast, consider GMC's 6-71 diesel. This engine has three ratings which are determined primarily by the life requirements in each application:

Continuous — Used in applications where load factors are high and life between overhaul is far more important than high specific output. (Marine work boats and continuous-duty generator sets.)

Intermittent — This rating covers a wide range of load factors and overhaul intervals in applications where specific output and life are both of considerable importance. (Highway vehicles, earthmoving equipment, and most industrial applications.)

Maximum — This rating is used when the highest possible specific output is desired. Life in terms of engine hours at this rating is relatively lower. (Marine pleasure crafts and certain military engines.)

Typical data for this engine are shown in Table 1. The continuous rating is based on an all cast iron engine (except for the blower, which is aluminum). The maximum rating is based on an engine with an aluminum block in addition to the other aluminum parts.

diesels of the immediate future (1962)

While there is always a desire for maximum output from a given size engine, the trend in this direction is not very strong in most applications. Considerations of engine life and fuel economy, to-

Table 1 — Present 6-71 In-Line Diesel Engine

Rating	Continuous	Intermittent	Maximum
Maximum horsepower (gross)	170	210 (+24%)	310 (+82%)
Maximum rpm	1,800	2,100	2,300
Weight, (fan to flywheel), lb	2,190	2,070 (−5.5%)	1,780 (−19%)
Plus turbo weight lb	None	None	175
Total weight (fan to flywheel), lb	2,190	2,070	1,955
Specific weight, total lb/max hp (gross)	12.9	9.85	6.3
Fuel consumption, lb/gross hp-hr	0.396	0.410 (+3.5%)	0.423 (+7%)
Volume, cu ft/100 hp	23.3	18.9	12.8
Engine material	cast iron	cast iron plus some aluminum	aluminum cylinder block

"Fan to flywheel" includes: blower
starter
generator
exhaust manifold

Truck accessory power (fan and generator) not included:

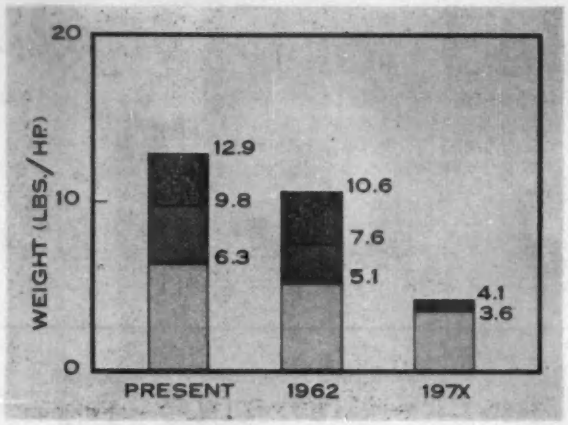
1,800 rpm	6.8 hp
2,100 rpm	9.8 hp
2,300 rpm	12.0 hp

The weights include: blower, starter, generator, and exhaust manifold.

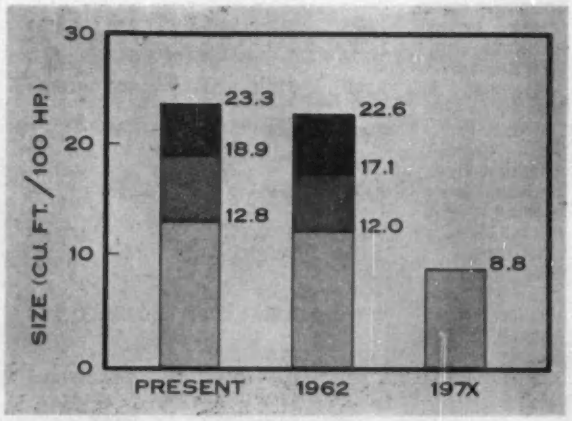
The running engine would require:

coolant:	78 lb (truck)	70 lb (stationary)
oil:	38 lb (truck)	51 lb (stationary)
radiator:		
industrial	67 lb	
truck	122.75 lb	
air cleaner, truck (2)	37.5 lb	

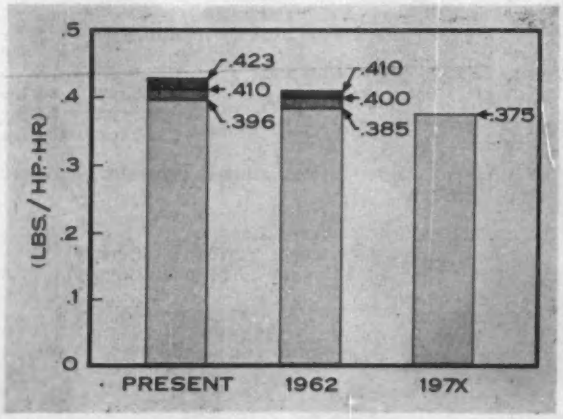
Diesel Promising for Future; Gas Turbine Slated for Larger Sizes . . . continued



Weight of GMC 6-71 diesel, present and future.



Size of GMC 6-71 diesel, present and future.



Fuel consumption of GMC 6-71 diesel, present and future.

Table 2 — Diesel Engines of the Immediate Future (by 1962)

Rating	Continuous	Intermittent	Maximum
Maximum horsepower (gross)	175	232 (222)	330
Maximum rpm	1,800	2,300 (2,100)	2,300
Weight, (fan to flywheel), lb	1,855	1,760	1,505
Plus turbo weight, lb	None	None	175
Total weight, (fan to flywheel), lb	1,855	1,760	1,680
Specific weight, total lb/max hp (gross)	10.6	7.6	5.09
Fuel consumption, lb/gross hp-hr	0.385	0.410 (0.398)	0.400
Volume, cu ft/100 hp	22.6	17.1	12.0

gether with legal weight and speed restrictions, tend to keep horsepower down in highway vehicles. In earthmoving equipment the demand for increased power is great, but again considerations of engine life make larger engines, rather than extremely high specific outputs, preferable. Only in the area of maximum rated engines is high specific output very desirable. We do not expect to make radical increases in specific output in the near future.

Minimum engine weight is, of course, desirable in all applications. Even in track-laying equipment where weight is needed for traction, it is cheaper to use pig iron than heavier engine castings. A new family of engines was designed to keep weight to an absolute minimum. Weights of the new 6-71 engines shown in Table 2 reflect this weight consciousness.

Fuel economy has become one of the most important single items governing the salability of engines for highway vehicles. We believe that this trend is certain to continue in highway vehicles and to become more and more important in other areas as well. We do not expect major breakthroughs in improved thermal efficiency, but rather a relatively steady progress in improved economy through careful attention to design detail.

Table 2 summarizes data for the engines planned for the immediate future.

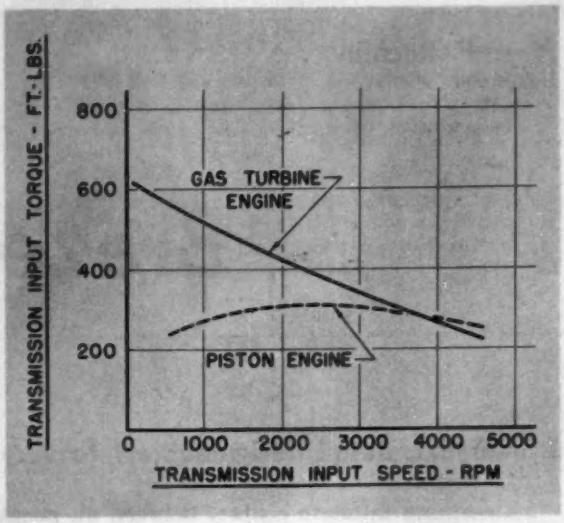
the diesel of 197X

There are two known methods of increasing engine output: by raising engine speed, or by raising bmep, or by a combination of both. Both methods increase thermal and mechanical loads on engine components and, therefore, require either hot strength materials or improved design to maintain life. Turbosupercharging of diesel engines has been and probably will continue to be the major method by which bmep increases are obtained. With improved high-temperature materials and rotor design made possible by gas turbine progress, higher pressure ratio and higher efficiency turbos will become available which will permit higher engine ratings.

Table 3 — Crystal Ball Diesel Engine (197X)

Rating	Maximum
Maximum horsepower (gross)	400–450 (+165%[a])
Maximum rpm	2,500
Weight, (fan to flywheel), lb	1,450
Plus turbo weight, lb	175
Total weight, (fan to flywheel), lb	1,625 (–26%[a])
Specific weight, total lb/max hp (gross)	4.06–3.61
Fuel consumption, lb/gross hp-hr	0.375
Volume cu ft/100 hp	8.8

[a] Based on Table 1, continuous rating



Comparison of gas turbine and piston engine torque.

Several years ago, a 6-71 engine was turbocharged to an output of 425 bhp or 1 hp per cu in of displacement. And this was achieved with a turbo of relatively low efficiency.

Today, it could be done more easily with lower stress on cylinder components because of better turbos, but the engine would still not have commercially acceptable life using materials and design techniques which would produce a commercially priced engine. The day when this can and will be done will certainly come. We can predict for the future a 6-71 turbocharged engine weighing 1600 lb and having an output of 400–450 bhp at a speed of 2500 rpm. Fuel consumption will be of the order of 0.375 lb per bhp-hr. (Table 3).

the gas turbine

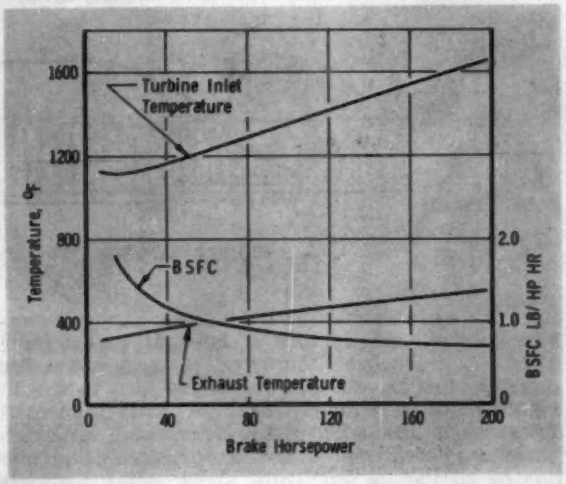
The attraction of the gas turbine lies in the fact that high outputs can be obtained in relatively small and light engines. Specific weights of 3–4 hp per lb are attainable in the 200-hp range. Jet engines (corresponding to the gasifier section of the vehicle turbine) delivering an equivalent of 1000 hp weigh 250 lb and have a fuel consumption of 0.6–0.7 lb per hp-hr.

This, then, promises to be an engine for very large earthmoving equipment, logging and mining operations, as well as mountain highway hauling.

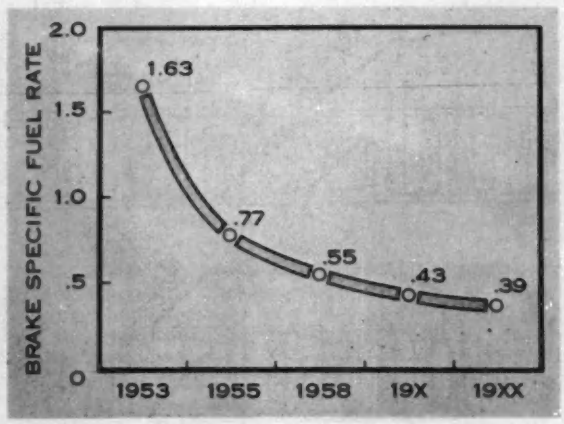
A 60,000 lb truck going up a 6% grade at 45 mph requires approximately 1100 hp. A turbine can readily furnish this much power. Since level road requirements are much lower, the part-load fuel consumption of a turbine, operating far below the design point, would be very poor. A compound powerplant may be attractive in which level road consumption is provided by a diesel engine of appropriate capacity.

Considerable progress has been made in the design for production. The cost of turbine engines, if built in quantities similar to truck engines, is estimated to be of the same magnitude as present diesel engines.

To Order Paper No. 71A . . .
. . . on which this article is based, turn to page 6.



Effect of gas turbine inlet temperature on fuel consumption.



Gas turbine fuel economy; past, present, and future.

Based on paper by

Floyd F. Rechlin

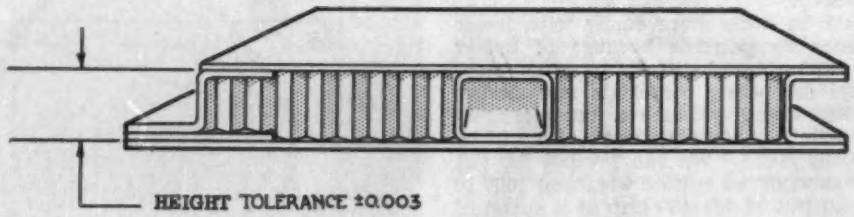
Solar Aircraft Co.

6 basic design

Brazed Honeycomb

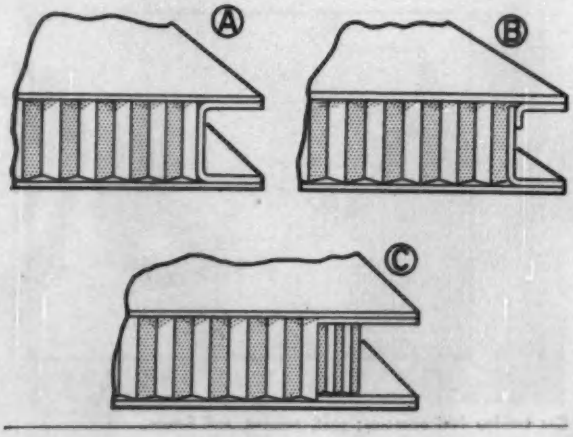
1. minimize detail design subject to very tight tolerance needs of brazing process.

Maintaining intimate contact between all members being bonded together is a basic requirement for brazing honeycomb sandwich. To achieve this contact, height tolerances in the order of ± 0.003 in. must be held on all integral parts of the assembly. The ability to do this, especially in the case of formed sheet metal parts, greatly influences producibility and cost.



In the design shown above heights of edge members, spar, and core blanket are all subjected to same ± 0.003-in. tolerance. Moreover, the core above the doubler must have a step machined in it to within ± 0.003-in. of the doubler thickness. This problem of tolerance is intensified if the honeycomb sandwich panel has curvature. In the manufacture of a panel having compound curvature, sheet metal members usually must be formed on a press brake, rolled, stretched, rerolled, and finally stretch-formed in order to meet the exacting tolerances and fit necessary for proper brazing.

The influence of these tolerances can be relieved by careful attention to detail design. The core blanket can be surfaced to an accurate dimension easily with electromechanical methods of machining, therefore, a practical design approach would be to concentrate height tolerances on the core and try to eliminate formed members with fixed heights.



The conventional channel member shown at (left) (A) illustrates this. If a small weight penalty is accepted, the channel can be redesigned as two adjustable angles, as shown at (B). After positioning to match the accurately machined core height, these two angles would be tack-welded to the core and the whole unit brazed to form a solid component. A still further improvement on edge member design would be to eliminate the vertical legs and substitute dense core to transmit panel loading, as shown at (C).

The primary design objective in all cases is to reduce the sandwich design to its most perfect form — a simple sandwich made up of core and facings with no other full depth members — for producibility. This is usually impossible, but proper attention to the design of incorporated components which are difficult to form within required tolerances will help to insure producibility of final configuration.

suggestions for

Sandwich

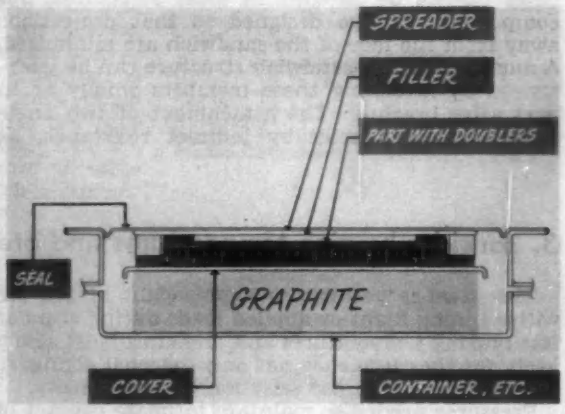
Here are down-to-earth suggestions for designing to achieve practical, producible, economical structures of brazed honeycomb sandwich.

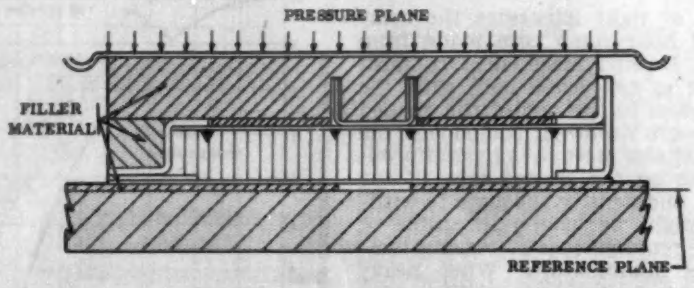
In the November issue the author will illustrate the use of some of these design suggestions by applying them to a hypothetical envelope configuration for a large missile wing.

2. make allowances for uniform brazing pressure and temperature distribution.

The need for uniform pressure planes and heat distribution is a requirement of the brazing process which could influence design. Here is shown a common layup method used to braze honeycomb sandwich. In this particular brazing fixture, partial evacuation of the container causes diaphragm movement against the part, with a pressure corresponding to the degree of evacuation. This pressure must be distributed equally on both sides of the panel being brazed to insure intimate contact of all parts at brazing temperatures.

The ideal brazing configuration consists of a completely flat honeycomb sandwich having no external steps or protuberances. Even minor deviations from this uniformity of surface must be compensated for by filler sheets or filler material, as shown, in order to provide even pressure planes on both sides of the sandwich. A small amount of filler can be tolerated. However, if the design configuration extends too far from the normal plane of the sandwich, the mass of the compensating filler material tends to become a heat sink, causing undesirable temperature gradients around the sandwich at brazing temperatures, which tends to increase the possibility of producing a partially brazed part.



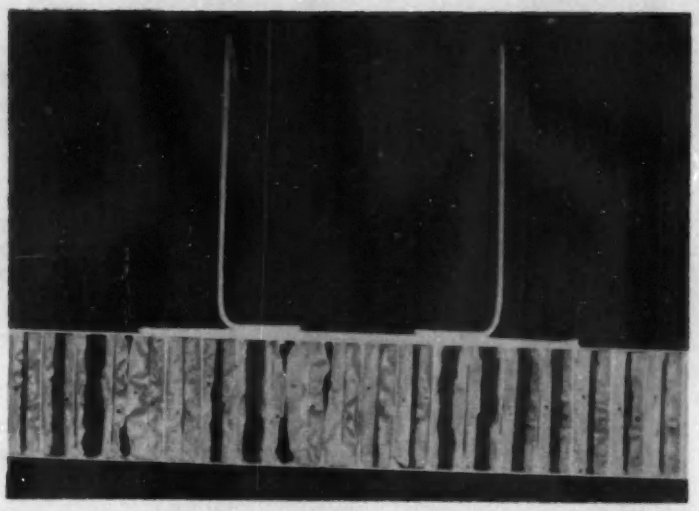


Incorporated in this hypothetical design are not only extended edge members but an external channel along the center of the panel and a doubler located on the opposite face. Filler material must be added, as shown, to maintain uniform pressure planes for brazing. Still, this will not guarantee perfectly distributed pressures on the face of the sandwich. The filler must have allowances made in its shape for differing thermal expansion between itself and the sandwich material at brazing temperatures. Thus, areas would occur, as shown by the dark triangles, where no brazing pressure would be experienced.

continued

Brazed Honeycomb Sandwich

. . . continued



. . . make allowances for uniform pressure and temperature distribution.

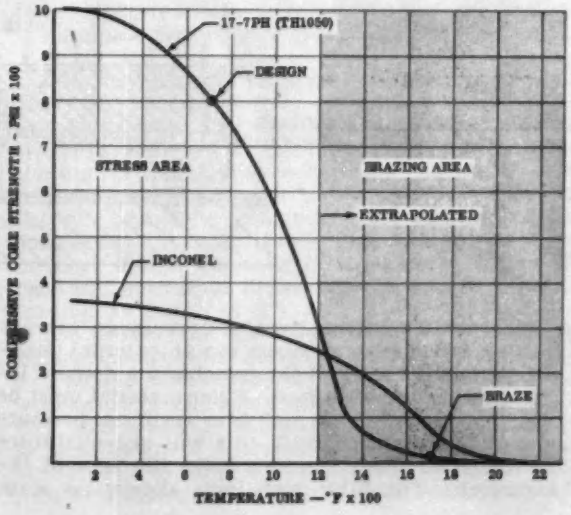
External stiffening members or attachment fittings cannot be avoided in most structures, but components can be designed so that projections away from the face of the sandwich are minimized. A more producible sandwich structure can be guaranteed by attaching these members wholly or in part after brazing. The attachment of two angle sections to a doubler by indirect resistance, as shown, effectively forms the desired channel section. By using such secondary attachment, the only filler material needed would be a sheet to compensate for the added thickness of the external doubler. Usually, it is preferable to resistance weld the doubler to the face sheet prior to brazing, although brazing of doubler to skin can be done successfully with proper use of stop-off material.

3. consider brazing temperatures and pressures in the choice of structural material.

This item is peculiar to light-weight brazed structures. Normal structural design is concerned with withstanding flight or applied loads during stipulated lengths of exposure at design service temperatures. But brazing temperatures and pressures must also be considered when designing brazed honeycomb sandwich, for they influence not only external configuration but also internal structural composition. This is reflected mostly in the selection of core density.

Pressures needed to maintain intimate contact of components being brazed are in no way equal in magnitude to those the structure must resist during service. Brazing temperatures may be as high as 2200 F. Moreover, brazing temperatures can be regarded as long-time service temperatures since they may range up to one hour in length, depending on fixture design.

The graph shown at right illustrates the compressive strength of honeycomb core made from 17-7PH/TH1050 and Inconel materials. In most designs the designer is concerned only with the physical property values to the left of the shaded area; with a honeycomb sandwich component the selected material must also meet the physical property standards shown on the shaded area of the chart. The core size and density adequate to withstand flight loads might be utterly incapable of meeting the pressure requirements at brazing temperatures needed for manufacture. When heavy gage faces, incorporated doublers, and/or edge members must be brazed together greater pressures are required than the pressure needed to hold the facings flat to the core blanket. These heavy pressures, due to uniform pressure distribution, must also be withstood by the core. Now, the only recourse a designer has is to consult his materials and processes group or brazing facility to determine if his selected core density is adequate to meet



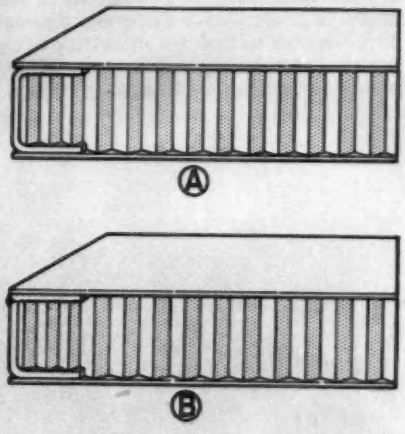
brazing pressure and temperature requirements. One general rule that might be applied is to avoid extremely thin foil thicknesses, 0.001 in. and below, unless the facings and edge members are relatively thin.

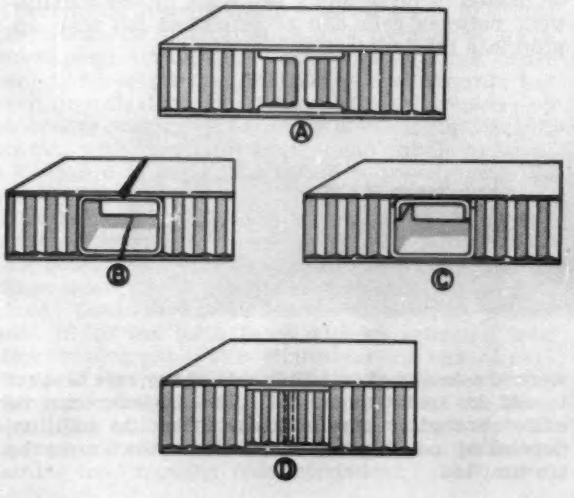
The brazing alloy designated by the designer may also govern the selection of core density. It is no great problem in this era of silver-base alloys. If high-temperature materials and brazing alloys are being considered, the metallurgical effect of the braze alloy on the core foil during brazing should be investigated.

4. insure that the design can be assembled for brazing.

Since honeycomb sandwich is made up of individual components which must be carefully laid up before brazing, part of the layup procedure is to make provisions to guarantee shear ties and structural adequacy by tack-welding together the core and vertical faces of included members. Intimate contact must be maintained between all parts of the assembly being brazed, and vacuum pressure accomplishes this in a direction normal to the plane of the faces. Mechanical or welding attachment methods must be employed, however, between the faying surfaces of all parts in the assembly not affected by these pressures. Therefore, provision to accomplish these ties must be made in the design.

In this hypothetical design, illustrating this type of design philosophy, an aerodynamically smooth closeout member is required at the edge of a honeycomb panel, as shown at (A). Channel section is a good choice in this case but, again, there in no way to get a proper shear tie between the core and the inner face of the channel section. One solution is shown at (B). Here the core is spot-tacked to the closeout angle, after which a doubler is welded to the angle to form the desired channel prior to brazing. If the aerodynamic smoothness requirement could be reduced, the design could be further simplified to two doublers separated by dense core acting as a replacement for the channel section web. A good approach is to make an exploded view of the design to insure that provisions are available for assembling the sandwich prior to brazing.





In this design the engineer is faced with the hypothetical problem of providing a structural spar through the center of a honeycomb sandwich. Conventional airframe design practice has established the I-beam section as a normal choice for this spar, as shown at (A). However, no way exists to establish a guaranteed shear tie between core and web of the I-beam. Even if an access method could be devised, it would be practically impossible to slip the core in between the caps of the I-beam section with only a 0.003-in. gap available to comply with brazing tolerances. For this reason, the ideal spar configuration is a box section.

The box spar design shown at (B) is formed by fusion-welding two channels together after the core has been spot-tacked to the individual channels. The design shown at (C) may be better from a producibility standpoint. But the design must

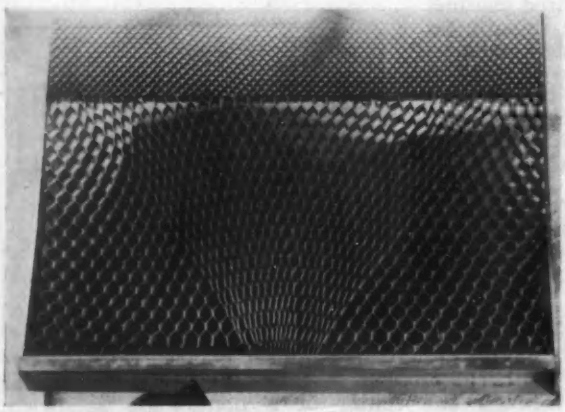
continued

provide for the insertion of a backup electrode to tack-weld the two pieces making up this box spar. The box beams introduce a weight penalty over standard I-beam construction, due to the double webs employed but this can be alleviated by using extruded or forged material, or by brazing doublers in place on top of the thin-gage channel sections.

Another method to provide a structural spar in a honeycomb sandwich is shown at (D). This design should weigh approximately the same as a standard I-beam spar by the substitution of dense core in place of the I-beam web. The spar caps are simple doublers with height tolerances entirely concentrated in the machining of the core between them. Tolerances are easily held in this type of construction.

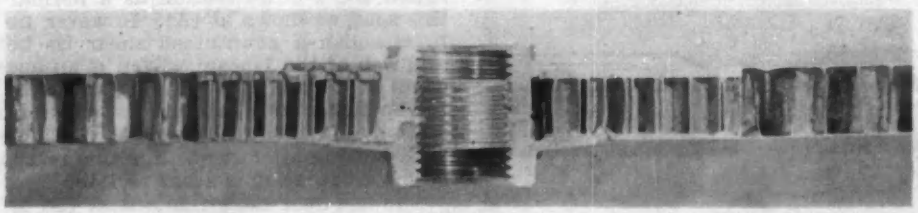
5. incorporate varying core densities to transmit loads internally.

The use of varying density core offers unlimited design opportunities. A certain amount of splicing is always necessary to get the final size and shape needed for a sandwich core blanket, hence it costs little more to incorporate different densities in these blankets beyond the cost of the core itself. Not only can densities be varied by inserting areas of smaller cell or heavier gage core, but sections of the normal core blanket can be shaped or crushed readily during the layup stage to form load carrying paths. Once the core has been spliced in place, it is machined and brazed as a unit to give a permanent internal structure.

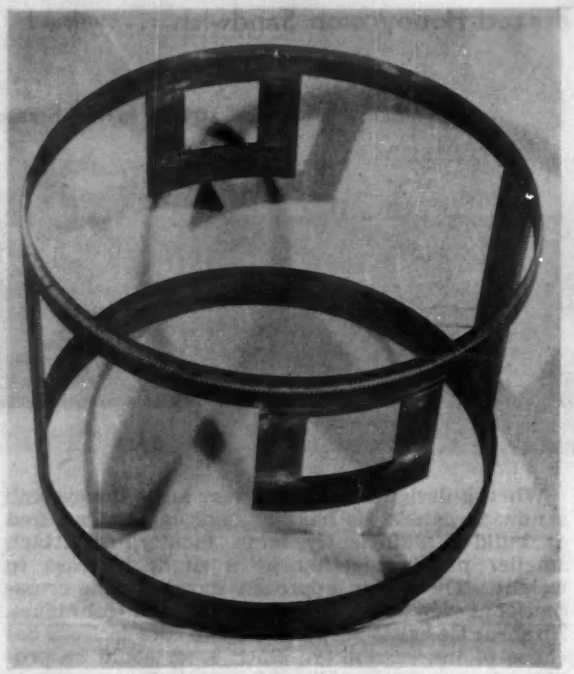


The edge members and core blanket for a small missile flipper represent a typical example of using varying core densities. Compressed core is used in a fan-shaped pattern to concentrate loads at a central section. The trailing edge is made up of smaller size cell core to permit feathering the core at the sharp trailing edge while still insuring maximum skin stabilization. If the normal core blanket with its larger cell structure had been carried out to the trailing edge, little or no face stabilization would have been available.

Use of smaller cell core also is recommended along the trailing edges of missile wings incorporating blunt edges in their design. The slight pitch of the exposed core walls usually provides a sufficiently smooth surface. If further aerodynamic smoothness is dictated, a strip of foil material can be brazed in place along the edge, or the indentations between cells can be smoothed out with appropriate filler material.



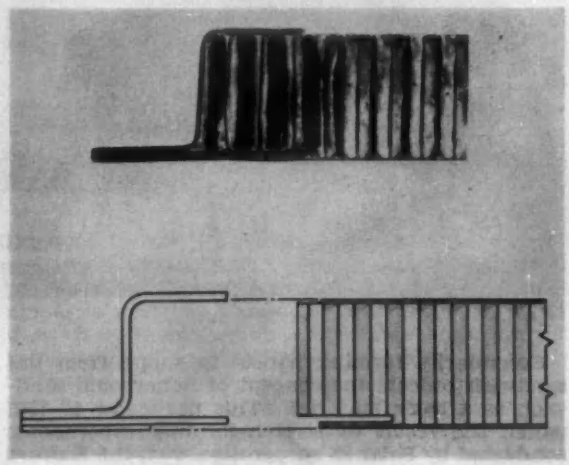
When design calls for fasteners in the sandwich, insertion of a small area of denser core in the parent core blanket offers greater local compressive and bearing strength. In this example of a fastener inserted through densified core, doublers were also included on either side of the core blanket to aid in load transmittal. The fastener can be either brazed or mechanically locked in position, depending on the degree of shear that must be transmitted.



Integral load carrying paths can easily be provided in honeycomb sandwich by designating an area of denser core. These paths sometimes can be created as a completely separate prebrazed assembly, as shown. Here the main cylinder framing consists of a brazed assembly of dense core and doublers. A secondary brazing incorporated the main core blanket and the facings.

6. attempt to treat honeycomb sandwich as a material.

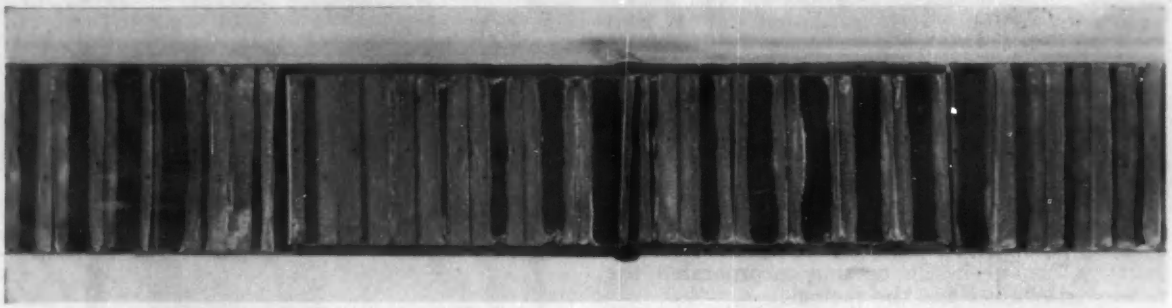
The time approaches when honeycomb sandwich can be regarded as a material rather than a built-up structure varying with each application. In the not too distant future, we can expect to be able to take flat honeycomb sandwich panels off the shelf, rough cut them to size, form them to the desired shape or curvature, finish machine them and attach the needed edge members by brazing, welding, or mechanical joining. Some of these methods are available now. Joining such panels and secondary attachment of edge members by welding and brazing appears feasible. By using variations of these techniques the designer can standardize on basic panels and greatly reduce cost.



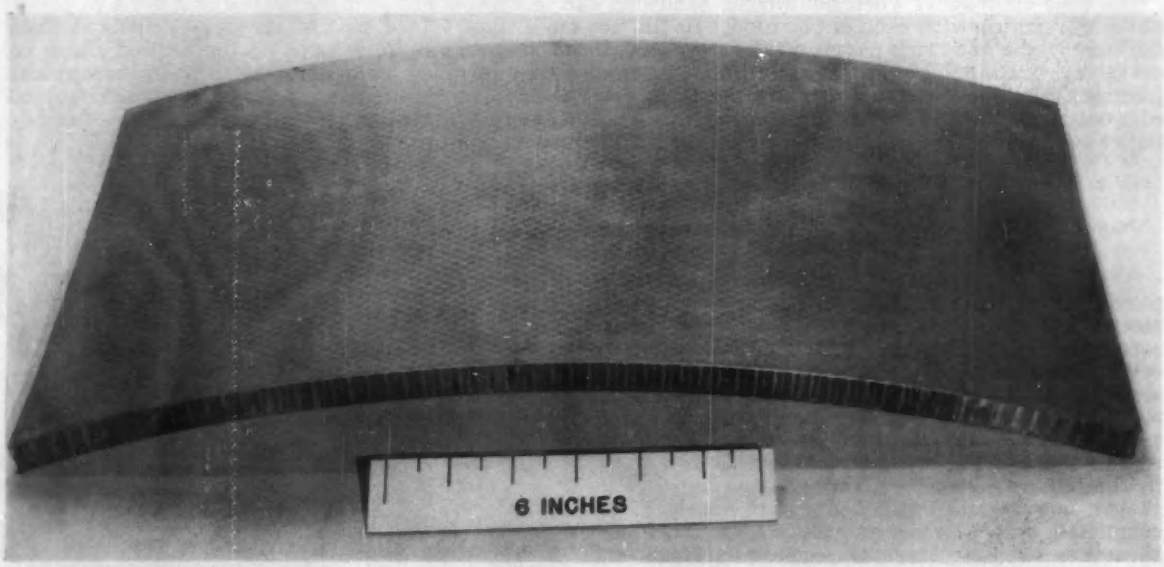
Secondary attachment of edge members to simple panels can be accomplished in a number of ways. Mechanical attachment, using doublers and dense core, is an established method. Solar Aircraft has been investigating attachment of edge members by secondary brazing. The intent is to accomplish this brazing with very large honeycomb panels by using a C-shaped furnace constructed to travel along the edges. The cross-section shows a typical secondarily brazed edge member and the accompanying sketch, how various components were added. The completed unit was structurally sound, including shear ties. The doubler was secondarily brazed in place. Doublers can be located successfully within 0.050 in. of the 0.010 faces without reducing load transfer strength. This eliminates the risk of cutting into the parent metal of the facing when machining a slot for secondary insertion of the doubler. The cell walls remaining after such a cut (as shown) and the deposited braze metal aid in maintaining load transfer characteristics.

continued

... attempt to treat honeycomb sandwich as a material.



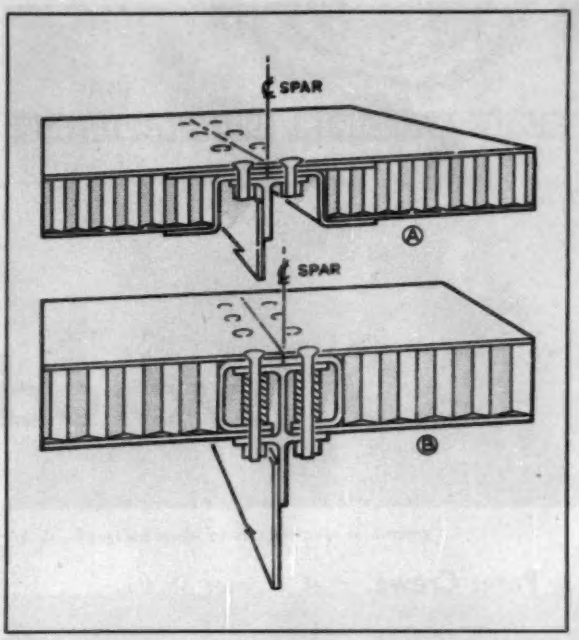
When a designer must use very large honeycomb sandwich panels, he has two choices. He can find or build a sufficiently large facility, or attach smaller panels together at a slight increase in weight. The design approach shown by the cross-sectional view is to join panels by weld techniques. No shear tie exists between the two core sections because of inaccessibility. Such a tie could be provided by machining the skins back far enough to expose the core for welding access. To eliminate the expense of such an operation and still offset the lack of shear tie, the core along the edges of each panel was densified to aid in transmitting loads into the doublers. Doublers are needed in such applications to alleviate the deleterious effect of welding on the heat-treatment of the individual panels. Welding experts should be consulted to minimize distortions or thermal stresses which might be built up by improper welding call-outs or weld locations. Tests on this type of construction have shown that cognizant welding does not disrupt the braze alloy underneath the weld, nor does braze alloy, in this case sterling silver, have detrimental effect on the physical properties of the weld.

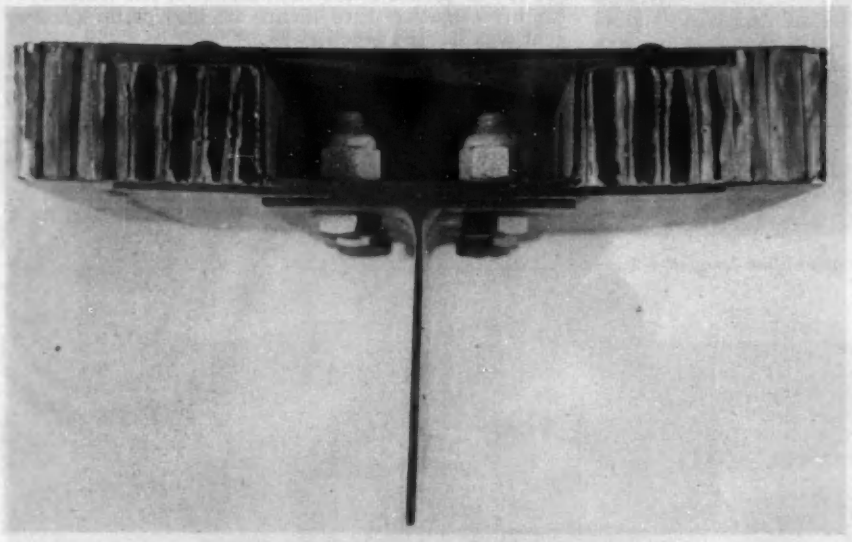


Secondarily forming panels to shape from flat sandwich reflects the concept of honeycomb sandwich as a basic material. This particular 17-7PH panel, the result of stretch-forming experiments conducted by Solar in cooperation with the Hufford Corp., was formed in the full TH1050 condition with elongation values in the order of 4%. Twenty-four inch radius panels have been stretched with no discernible core crushing. Many problems remain to be solved, such as degree of springback and elimination of bowing, but the process has promise for future designs.

Once a honeycomb sandwich has been brazed it becomes a structural material of finite thickness. Tranferring loads adequately from both faces through mechanical joints, while accommodating this established thickness, can challenge a designer. The problem is exampled by this wing-to-spar section. In most cases, access is not available for mechanical fastening on the inside because of the sealed closure requirements of the modern day "wet" wing. The design shown at (A) offers easy access for panel replacement but introduces an undesirable weight penalty. The Z-section and doubler combination must be heavy enough to transfer loads from the inner skin of one panel, up over the spar cap and down to the inner skin of the adjacent panel.

The most efficient way to transfer loads would be directly through the spar cap without directional change, as shown at (B). To unfasten the panels from the outside and still insure a mechanical tie would require using some kind of spacer. Locating the spacers could be a monumental task and their weight together with that of the extended length bolts is undesirable. Moreover, the interlocking effect produced between the extruded spar cap, channel edge members, and spacers could make panel removal difficult.





One possible solution is to transfer loads directly across a cap strip, which is welded in place on the outside of the sandwich after the panels have been bolted to the spar cap. To replace these panels, the cap strip could be ground off, and another strip welded in place upon completion of the bolting. Such joints should be designed to minimize shrinkage and thermal stresses due to welding. By using proper welding and mechanical fastening techniques, a designer should be able to devise many ways for accomplishing an efficient transfer of loads and still accommodate the fixed sandwich thickness.

To Order Paper No. 82C . . . . . on which this article is based, turn to page 6.

SAE LOOKS OVERSEAS

A feature of the SAE Overseas Information Advisory Committee

some aspects of hydrodynamic model

by **Peter Crewe,** chief engineer (hydraulics), Saunders-Roe, Ltd., who tells of the lesser known aspects in this field.

THE test tank facilities of Saunders-Roe Co. at Cowes, in the Isle of Wight, England, have a number of rather unusual features.

Privately Operated Company

They are operated as a private company — as a business, undertaking hydrodynamic research and development, both for individual customers and for commercial and Government organizations. The company makes a modest profit without benefit of subsidy.

A wide range of work is undertaken. The tanks were first used for developing and proving the hull designs of water-based aircraft produced by Saunders-Roe. Later they were used for ditching of landplanes to determine airworthiness requirements — and the testing of ships, high-speed motorboats, and yachts. Nowadays, even more unorthodox objects are towed in and under the surface of the water .... An investigation into means of improving trawler gear was started recently.

Three types of tests are undertaken:

- Hull tests for *pleasurecraft* — yacht tests such as those recently instrumental in determining the

Fig. 1 — Yacht hull under test with heel and leeway.

testing

choice of David Boyd's design of "Sceptre," the British contender for America's cup.

• Landplane ditching tests for *safety* — made for both home and overseas aircraft organizations.

• Tests to determine *superiority* of flying boat hulls. (New flying boat designs are greatly superior to the old, although this has not received adequate recognition by way of construction of new operational types.)

Yacht Tests Included Nine Models

Nine models were tested in choosing "Sceptre." Two hull forms each were offered by the well-known designers Charles Nicholson, David Boyd, James McGruer, and Arthur Robb. The ninth model (Laurent Giles' Flica II) was used as a yardstick because its full-scale performance was well known.

Tests were made in calm water. The hulls were assumed to be "well balanced" so that negligible helm was required. "Gimcrack" sail forces — developed by the Stevens Institute of Technology Towing Tank (of Hoboken, N.J.) — were applied, since full-scale tests (such as those made on the 5.5-meter "Yeoman") have been shown to provide very good agreement between model and full-scale behavior. These sail forces were no doubt also assumed for the recent America's Cup tank tests undertaken in the United States.

The models are so propelled by the dynamometer that they heel over and make leeway in a representative manner. This is done by fitting a stub mast having a Hookes universal joint located at the theoretical center of sail effort. The joint is attached to a vertical post which is free to move up and down. Appropriate vertical, driving, and side force components are applied to the post by a weight and two hydraulic pressure capsules, respectively. (See Fig. 1.)

During each run it is necessary to move the posi-

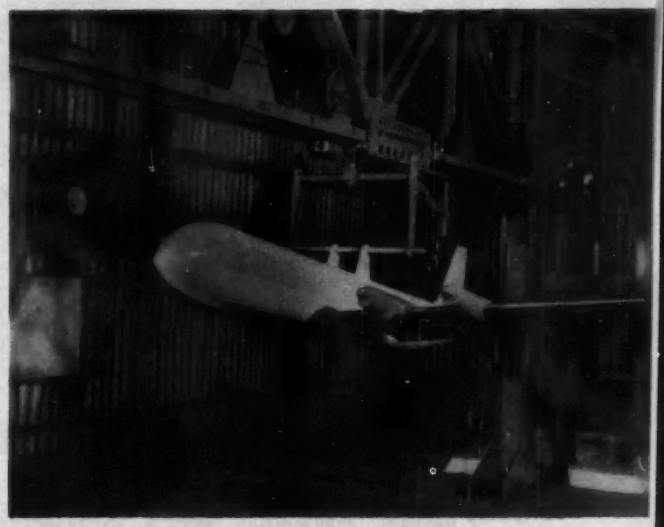


Fig. 2 — Vanguard model on catapult prior to ditching.

Fig. 3 — Vanguard model being ditched.

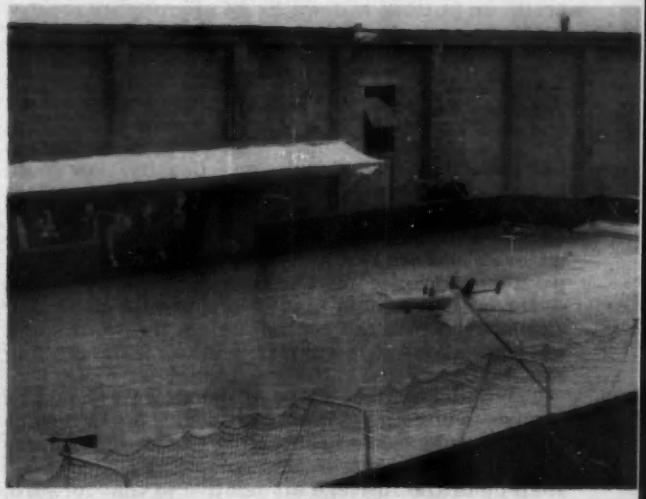


Fig. 4 — General view of ditching tank with hydroski-supported model.

some aspects of

hydrodynamic model testing (continued)

tion of the dynamometer carrying the capsules vertically until they are in line with the center of the Hookes joint. The latter varies in height with change in the orientation of the hull, and in particular with heel and speed.

Variables Recorded & Crossplotted Many variables are recorded during each test run — such as side force and resistance, and angles of heel, pitch, and leeway. Results are then crossplotted to determine the equilibrium sailing conditions appropriate to given sail force assumptions . . . and the corresponding best-speed-made-good-to-windward is computed.

Simple tests of upright resistance are also made.

Great care is given to correct interpretation of data. In the case of our America's Cup tests, an independent practical expert was employed by the syndicate of yachtsmen sponsoring the work to decide on the best design submitted.

Systematic development tests on a family of related hull forms would appear to be the best way to arrive at optimum design. Unfortunately, time was not available. In parallel U.S. tests, however, it is understood that results on a particular model were employed to compute the optimum hull size allowable within the class rules.

Even the race itself will not provide a criterion of tank-test methods since the skill of the crew counts for so much.

Ditching capabilities of a landplane depend generally on putting it down in an appropriate configuration . . . and upon observance of certain simple design criteria. (Figs. 2 and 3). Determination of

Landplane Ditching Tests best method of approach — whether fairly fast and fine, or with full flaps and at as low a speed as possible — requires model tests or previous experience on craft of similar design. Usually, slow speed is advantageous. Flight path to the horizontal at impact should not exceed 1 or 2 deg, and the portion of the airframe making initial contact with the water should be at an incidence of some 6 deg. Every possible allowance must be made for wind and waves — for landings being made along crestlines of long swells, even in a cross-wind, unless the wind speed exceeds about one-quarter the aircraft stalling speed.

The under-surface shape of the aircraft should be such as to discourage nosing or sucking-in, or bouncing-off tendencies on contacting the water. Appropriate and in general aerodynamically acceptable shaping of the fuselage aft relative to that forward, and proper attention to the effect of undercarriage fairings and underslung appendages, are necessary. The aircraft must also be structurally strong enough to sustain water impact forces and pressures without catastrophic failure.

A strongly swept-up-aft fuselage will tend to squat on impact due to rear suction. This can lead to a bounce-off and severe second impact. Failure of access hatches or undercarriage doors — exposing bulkheads which take the full longitudinal force of the water — may impose powerful nose-down movements . . . . The aircraft may even dive beneath the water.

There have been cases recently where the fuselages broke in half just aft of the wing because of severe loads imposed on the rear end.

Methods for greatly improving ditching characteristics are well known. For example, a nose wheel door can be designed to act as a hydroski. So far, the small weight penalty has proved unacceptable to the operator.

Very recent developments indicate some possibility of employing special hydrofoils more efficiently than hydroskis. This leads naturally to recent water-based aircraft developments of the hydrodynamic type.

Change in Hull Length-to-Beam Ratio A major change has occurred in hull length-to-beam ratio. This was once of the order of 7/1, but is now 10/1 to 12/1. This difference is due to the discovery that the load that can be carried efficiently on a given bottom area varies almost as length squared times beam . . . so that the greater the length/beam ratio becomes, the smaller the area can be for a given load. Aerodynamic and hull-bending-moment considerations obviously set an upper limit to the fineness ratio that can be used.

Proper proportioning and fairing of the region around the main step have very substantially reduced air drag. More extreme fairing is possible if air is vented to the step. Keeping the afterbody rather longer than the forebody and placing the rear step at the aft point of the aircraft reduce the possibility of skipping off when landing in severe seas.

Hydroskis placed below the hull forebody, and designed to retract into the bottom in flight, substantially increase the rough water capability by reducing impact shocks and improving the spray clearance of engines, flaps, and tail surfaces. (Fig. 4).

Hydroskis-Hydrofoils Used High-speed hydrofoils — in which air is ventilated to the upper surface — are now showing promise of providing a substantial breakthrough with regard to rough water capability and hydrodynamic efficiency. Impact accelerations have been reduced to one fifth the values experienced by hulls alone in the same sea conditions. Seas up to 8 ft high or even 12 ft high can be designed for . . . and open ocean operation is becoming increasingly possible.

The foregoing is just one aspect of the many new angles that are being explored in hydrodynamic facilities today.

new open ejection seats . . .

. . . provide safe escape over a wide range of airplane speeds and altitudes. But closed escape capsules may be required for future weapon systems.

Excerpts from paper by

Arnold I. Beck, human factors specialist, design safety section

and

George Hildebrand, senior group engineer, escape systems

Republic Aviation Corp.

A VERITABLE crash program has been conducted by the aircraft industry and the military to fill the immediate need for extending the usefulness of the open ejection seat escape system.

A group of Air Force contractors joined together to form the Industry Crew Escape Systems Committee, known as ICESC, in an effort to accelerate this endeavor. This work, plus the work being done on an individual basis by the various contractors and in the laboratories of the Air Force and the Navy, promises dramatic results. We may soon achieve maximum safe escape potential without undue penalty to the weapons system.

Here are the accomplishments in fulfilling the essential design requirements:

Ejection Acceleration and Separation

• Positioning and restraining devices built into the seat with automatic harness reels provide for correct body alignment, enabling the occupant to withstand the ejection forces required to effect adequate tail clearance. In the past vertebral fractures and associated injuries have been the major causes of aircrewman disablement during or following escape from the aircraft.

• Rocket-catapult combinations offer the sustained burning rate desirable for maximum ejection trajectories, particularly important for ground level escape.

Dynamic Stability

• Ejection seat configurations undergoing extensive testing at this time offer a miscellany of stabilizing devices including systems of fins, booms, vanes and parachutes, used singly or in combination. Much work has been done to simplify and increase the reliability of these devices. Incapacitation of aircrew personnel as a result of excessive rates of spinning or tumbling or both can be more serious than disablement by gunfire.

Deceleration and Windblast

• Excessive deceleration forces are counteracted by the rocket catapult. Sustained burning time with the thrust line acting through the center of gravity of the ejected mass appreciably reduces deceleration effects.

• A weight/drag ratio more favorable to lower decelerations is inherent in the new higher-density seat configurations.

• Launching the seat in a trim attitude or rotating the seat by aerodynamic devices to this attitude, reduces frontal area for beneficial deceleration effects and simultaneously provides a large measure of windblast protection for the occupant.

• Peak deceleration forces are distributed over the

new open ejection seats

. . . continued

torso because windblast pressures act to relieve concentrated deceleration forces.

High Altitude

- Complete reliance can be made on personal pressure suit with independent pressure and oxygen supply as part of ejection seat equipment. This equipment serves, if necessary, during an emergency fly-down of the aircraft as well as for the escape process if this has to be initiated above 45,000 ft.
- Ejection at very high altitude involves a critical free fall condition. After the stabilized seat has overcome the ejection, deceleration, and peak temperature rise effects, the pilot may be automatically separated from the seat and descend to a survivable altitude or ride the entire assembly to the ground. Adverse spinning and intolerable body rotations are inhibited by his reefed personal chute or drogue. Suit pressure and oxygen are supplied from his survival equipment.
- The recent advances made in personal high altitude protective clothing, oxygen systems, ventilation garments, survival-exposure gear, and related equipment have, for all practical purposes, nullified previous altitude ceilings as limitations on ejection seat systems.

High Temperature

- Adiabatic temperature rise protection devices include use of leading edge cones and plates.

Low Altitude

- Low-speed, zero-altitude bailouts have become completely practical with the aid of the rocket catapult of relatively low thrust (6500 lb). The simplicity of the even more sophisticated ejection seat systems means minimum time lags between pre-ejection functions.
- A zero-speed, zero-altitude system is possible. Successful ejection capability from a flaming aircraft on the ground will soon become a reality.
- Safe high-speed, low-altitude ejections at dynamic pressures to 2500 psf is the present goal of the modern ejection seat escape system.

Landing and Post Landing Conditions

- The pilot manipulating his chute has greater opportunity of selection of landing site.
- Environmental protection is offered by survival gear containing basic equipment required for existence on the terrain over which mission is planned.

The main disadvantage to ejection seats is, of course, that there is likely to be restricted normal cockpit activity and possible high fatigue factor due to the multiplicity of complex garments worn for emergency conditions. The ventilation garment, pressure suit, exposure suit and boots, and other necessary gear become very burdensome.

Crew escape capsules, on the other hand offer the possibility of aircraft flight in "shirtsleeves."

The ejection seat escape system is adequate for a large performance envelope. But it may not be adequate for certain future weapons systems. If analysis discloses that a sufficient flight interval exceeds ejection seat envelope, or that certain disadvantages of the seat system become untenable, the crew escape capsule may become a must for maximum weapons system effectiveness.

The newest concepts of escape capsule design envision a "minimum size configuration" or what amounts to an enclosed ejection seat. The effect on aircraft gross weight has been reduced considerably. While the ejected weight (inculding occupant) of the supersonic ejection seat has grown to about 500 lb, the equivalent weight of the capsule will be about 850 lb. Minimum size offers advantages of installation within normal cockpit ejection envelope, favorable weight/drag ratio, comparatively low rocket catapult thrust requirements, and reduced vulnerability to aircraft fire or battle damage.

A comparative analysis between the supersonic ejection seat and the "minimum size" capsule escape system for similar design conditions shows:

Ejection Acceleration and Separation

- The capsule requires considerably larger separation forces, and in the case of large size capsules, the thrust requirements may become critically high.

Dynamic Stability

- Stability device complexities are similar for both seat and capsule. The capsule, being completely enclosed, has the advantage of better configuration and center of gravity control, thus perhaps simplifying stabilization requirements.
- Bluff-shaped capsules tend to offer certain advantages of inherent stability, minimizing the need for stabilization devices and possibly avoiding the need entirely.

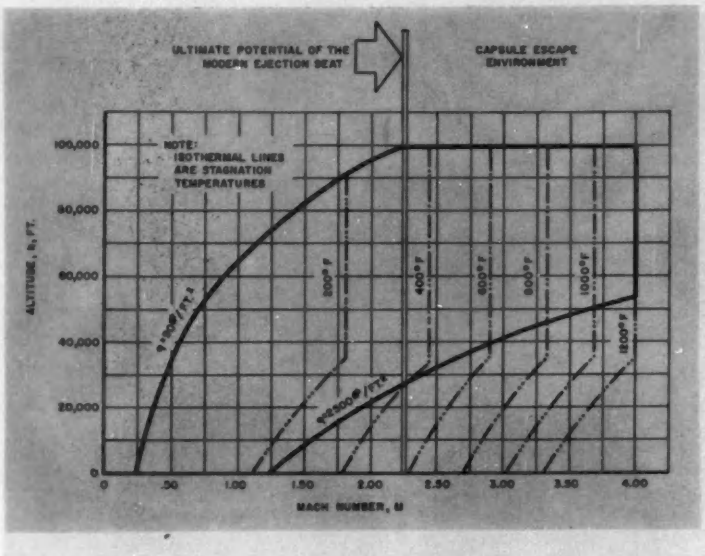
Deceleration and Windblast

- High-fineness-ratio capsule shapes have the advantage of reduced deceleration loads. However, the reduced loads act over a much longer time period which may be an offsetting factor.
- Bluff-shaped capsules are subject to higher deceleration forces but for short durations only. This type of capsule, designed so as not to exceed the limit of human tolerances to the parameters of high decelerations, rates of onset, and their durations, will provide capability for low level, high q ejection sequence.
- Windblast effects on the pilot in capsule are non-existent. However, the capsule subjects the pilot to higher concentrated forces at harness restraint points, which eventually might require use of torso girdles.

High Altitude

- The enclosed-seat type of capsule may be used

A FUTURE ISSUE will carry a discussion of the considerations in choosing an escape capsule conguration, based on paper, "Some Fundamental Considerations in the Selection and Design of Escape Capsules," by Donald M. Root, Northrop Aircraft, Inc.



Mach Number — Altitude Envelope for Hypothetical Airplane

for emergency fly-down following pressure loss in the cockpit.

• The stabilized capsule provides excellent pressure/oxygen environment for occupant during free fall from altitude.

High Temperature

• The capsule provides a greater degree of protection to the occupant against adiabatic temperature rise. This is particularly true with bluff-shaped bodies, which have low heat transfer characteristics.

• The capsule provides protective environment when enclosed within the aircraft upon failure of the cockpit refrigeration system at high Mach number flight conditions.

Low Altitude

• At low or high speed the escape capsule's low-altitude capabilities are compromised by increased complexity and resultant time lag functions.

Landing and Post Landing Condition

• Since the pilot uses the capsule as an escape medium to ground, the capsule must shield the pilot against ground impact conditions up to 40 *g*'s. Thus suitable energy-absorbing structure must be provided. Flotation gear must be deployed automatically for water landing.

• Jam-proof escape provisions must be provided for the pilot to permit uncomplicated egress from the capsule after touchdown. Auxiliary escape hatches may be required.

• The capsule can offer a degree of protective shelter in extreme climates and environments.

The principal advantage of the enclosed capsule escape system is that secondary provisions are available to the pilot in the event of pressure loss or refrigeration system breakdown. This makes possible the so-called "shirtsleeve concept" of aircraft operation. It must be remembered however, that pilot comfort notwithstanding, these secondary systems are not nearly so reliable as the presure/vent suit combination.

The secondary means may fail simultaneously with the primary means, since they are a portion of a larger and more complex system than the pilot's personal equipment.

Furthermore the doors and hatches which are part of the enclosed capsule system may offer equally serious restrictions to mobility and access within the cockpit. It must be pointed out also that the capsule is more susceptible to battle damage of a type that can be survived by the aircrewman, who then needs an escape system for an escape system.

Failure of a stabilizer on an enclosed capsule may throw the system into excessive rotational movements. The ensuing dangers are predictable because human tolerances to rotation are known to reasonably exact limits. For example, with the center of rotation about the heart, 60 rpm is tolerable. But negative *g*'s come on at 80 rpm and are tolerable for only a few seconds at 125 rpm. Positive *g*'s prevail at the legs and numbness and pain occur at 90 rpm.

With the center of rotation at the hips, negative *g*'s come on sooner and with greater intensity. Head pressures are unpleasant at 70 rpm and intolerable between 85–90 rpm. Capillary walls will rupture at pressures above 70–80 mm Hg (between 30–40 mm Hg if sustained for 1–2 min). Studies indicate that pressures of 80–100 mm Hg are the limit of human tolerance. A pressure of 80 mm Hg corresponds to 110 rpm with the center of rotation at the heart or 80 rpm with the center of rotation at the hips.

Significantly, it must be pointed out that dummy drops have produced combinations of tumbling and spinning equivalent to 180 rpm.

So, as to whether it shall be open ejection seat escape system or capsule escape system, the designer can make a valid choice only when more knowledge and data concerning human capabilities and requirements are available.

To Order Paper No. 91C . . .
. . . on which this article is based, turn to page 6.

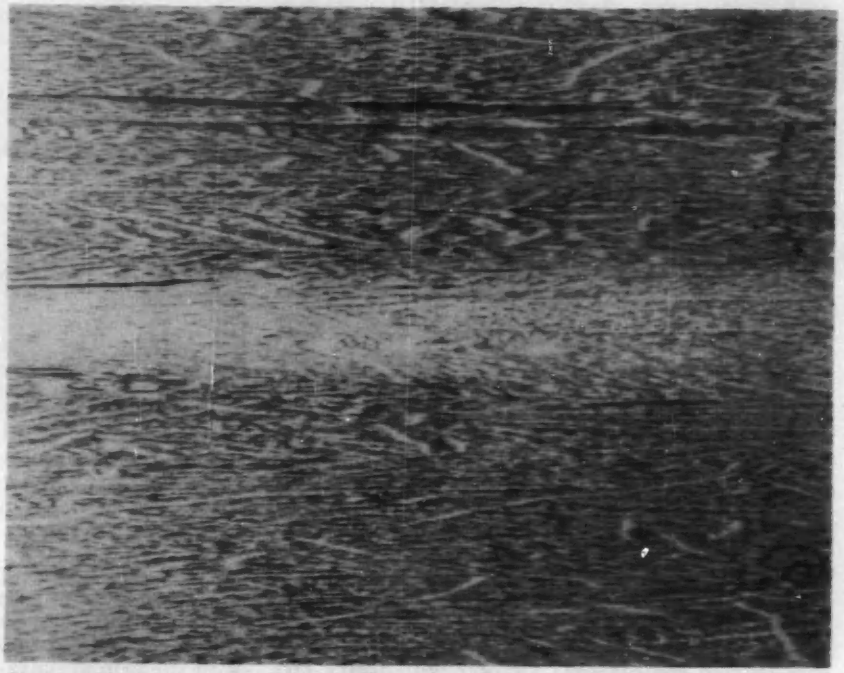


Fig. 1 — Severe banding shows in this photomacrograph of a portion of a part made of "aircraft quality" SAE 4340 steel. This kind of banding seriously impairs strength of the finished product.

Meticulous selection of billets plus great care in machining, heat-treating, and finishing makes feasible . . .

The Processing of Wrought

Based on paper by

L. H. McCreery

supervisor of engineering structures materials
Chance Vought Aircraft, Inc.

THE processing of SAE 4340 steel to high strengths is completely feasible, provided several important precautions are carefully followed. It's essential to take care that:

1. The steel you use has the capability to be heat-treated to high strength with significant ductility.
2. The rolling or forging process is performed in a quality manner with no over-heating or burning.
3. Machining processes are performed carefully and completely.
4. The heat-treatment used is completely adequate as to process, times, and temperatures.
5. The part is not ruined in the finishing operation through embrittling or cracking under the finishing material.
6. Your inspection checks of vendors, processes, and parts are both adequate and frequent.

High-strength wrought steel as a member of the family of available materials for airframe construction is here to stay. Aircraft like the Crusader and missiles like the Regulus owe their high performance characteristics in part to the weight saved through use of high-strength steel parts — structural parts at 260,000 psi minimum ultimate strength.

Raw Material

Chance Vought's first attempts to use wrought steel at strengths above 220,000 psi brought clearly into focus the importance of the structure imparted to the ingot during solidification. To be successful in using parts heat-treated to high strength, you must start with good sound aircraft quality steel.

Fig. 1 shows the degree of banding observed in a product made of steel supposedly of aircraft quality. Fig. 2 shows the microstructure in this band after the specimen had been normalized twice at 1625F,

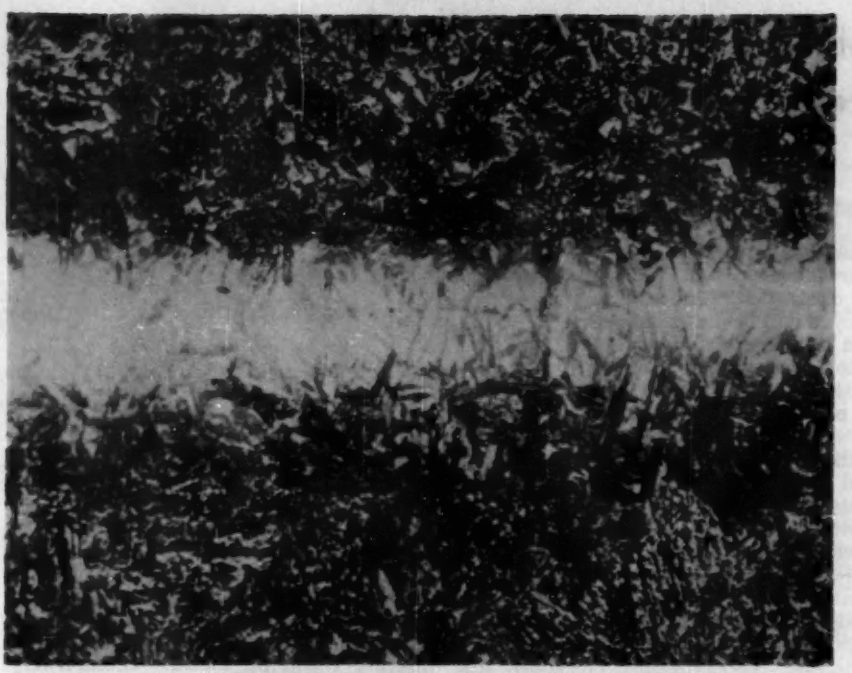


Fig. 2 — Banding shown in Fig. 1 persisted even after specimen underwent a double normalizing treatment and a quench and temper prior to a full anneal. Apparently nothing will break up the banding. (Reproduced from photomicrograph at 500 × magnification.)

Steel to High Strength

austenitized, quenched, and tempered at 450F for 4 hr, then given a full annealing treatment. Apparently nothing will break up this banding.

To avoid such steel a specification containing a requirement for guaranteed transverse properties was prepared.

Once suppliers willing to try to meet the specifications were found, an extensive educational program concerning specimen preparation appeared necessary. Using the best known techniques in preparing specimens for tensile test, reliable reproducible results can be obtained on this steel — even though it was formerly supposed to be "brittle as glass" when heat-treated to Rockwell C50 or higher.

Fig. 3 is a histogram showing the experience at Chance Vought in procuring steel to our special requirements for transverse properties. These data were compiled from tests of specimens taken at the mid-radius location. All heats of steel which have been tested for or by Chance Vought have been tested at the center location as well as the mid-radius location. Fig. 4 shows the results of the center tests which, although made until now "for information only," give reason to launch a campaign for establishing guaranteed center-test minimums.

We believe that such a stand is justified since it is apparent that mid-radius tests from heats having low center properties exhibit far more scatter in properties than those from heats having more desirable center properties. We believe also that a macro-etch quality requirement must become a part of any procurement specification for wrought steel, particularly for the high-strength applications.

Hot Working

To avoid ingot segregation as far as possible, employ the smallest ingot which will still permit a significant amount of working in the preparation of the mill product.

If the metal in the ingot is of high quality the exact reduction procedure can vary considerably with barely noticeable effect on mechanical properties.

The Processing of Wrought Steel to High Strength

continued

It may be done by rolling, forging, or a combination of both.

The forging operation employed in producing forgings for heat-treatment to the Rockwell C50-53 range must also be carefully controlled. The results of any poor techniques employed will be magnified at this hardness. (This should not be construed as a recommendation to eliminate forgings from articles produced to the high-strength range but rather as a recommendation to employ only high-quality forge shops and forgings.)

Fig. 5 is a macrograph of the fracture surface of a steel forging which snapped in two when the machine shop attempted to straighten the forging after it had been heat-treated to Rockwell C34-38. (Parts to be heat-treated to Rockwell C50-53 are frequently heat-treated to Rockwell C34-38 for machining, then later re-heat-treated to the final required hardness.) Fig. 6 illustrates the micro-structure near the fracture. Burning and serious overheating can both be seen.

Investigation of this difficulty brought to light several disturbing factors, any one of which is sufficient cause for procuring steel forgings only from those shops adequately equipped with personnel and controlling equipment. These facts were uncovered:

1. The die forging was being produced with forging equipment entirely too small for economical production.

2. Heating equipment was such as to allow flame impingement on the blank.

3. Thermocouples were inadequate in number and improperly located.

4. The operator was compensated on a per piece basis.

5. Inspection consisted of dimensional checks only.

It became obvious that the operator was using a dangerously high heating temperature, resulting in frequent instances of over-heating and burning. No doubt he used this dodge to compensate for the under-powered equipment as well as to shorten the time needed to get the required configuration. When a lot of forgings was produced using the same operator and equipment but employing drastically different techniques under the surveillance of Chance Vought engineers, not a single area of even slight over-heating could be found. Incidentally, the resolution of this one incident cost Chance Vought more than $100,000 — not counting an elu-

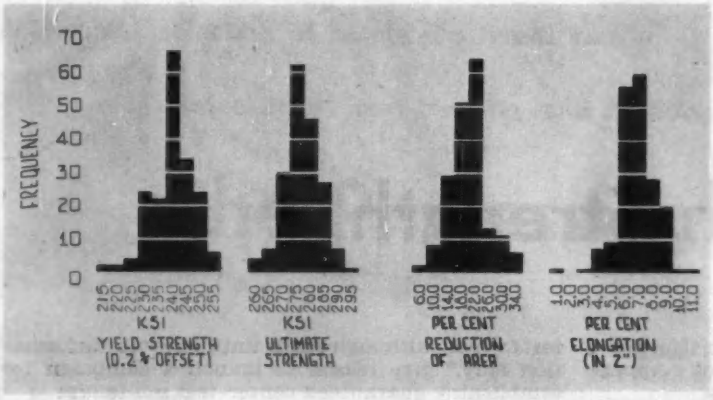


Fig. 3 — Specimens from mid-radius of billets showed these properties.

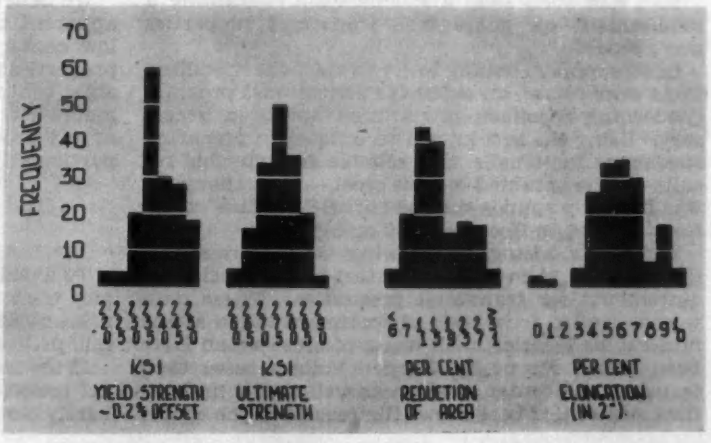


Fig. 4 — Specimens from center of billets showed these properties. Heats having low center properties exhibit far more scatter in mid-radius properties than those from billets having more desirable center properties.

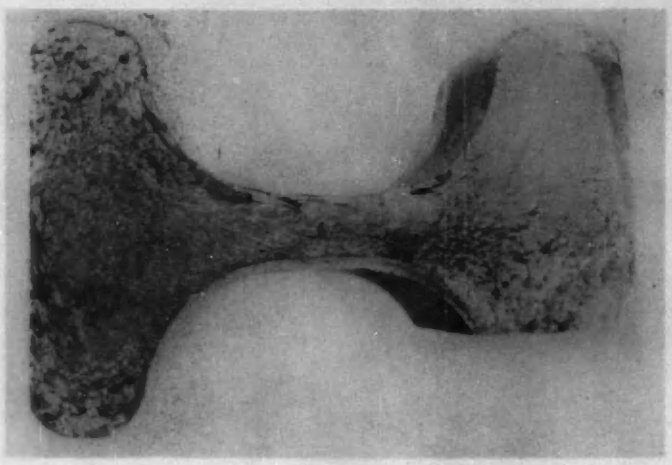


Fig. 5 — Die forging which had been overheated snapped in two, giving this fracture surface, when the machine shop attempted to straighten the forging after it had been heat-treated to Rockwell C34-38 for machining prior to re-heat-treatment to Rockwell C50-53.

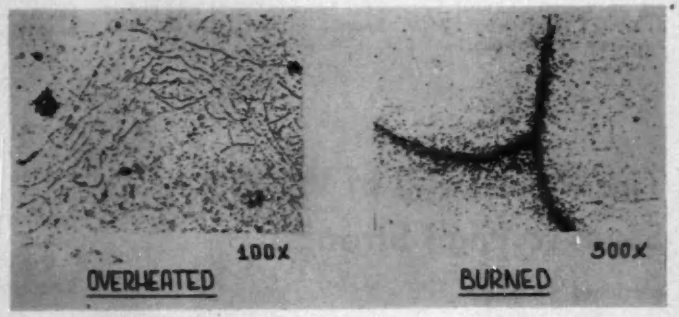


Fig. 6 — Photomicrographs of overheated and burned steel observed in a die forging from the same lot as the one shown in Fig. 5.

sive amount made up of the cost of added inspection, added testing, and disrupted schedules.

Machining

The machining of parts which have been heat-treated to high strength presents quite a problem. In recognition of this fact the Chance Vought specification for processing high-strength steel parts gives the processor these options:

1. Rough machine to 125 RMS (maximum), heat-treat, then finish machine.
2. Finish machine, then heat-treat using (a) a neutral salt bath, (b) a controlled atmosphere with precise carbon potential control, or (c) copper plate prior to heat-treating.

Where machining is performed on the heat-treated part it is recommended that single-point carbide tipped tools be used and that cuts be no more than 0.006 in. per cut. Grinding is limited to a depth of 0.002 in. maximum, using a soft wheel and followed by light shotpeening.

These restrictions have led to the practice of machining before heat-treatment.

Heat-Treatment

The largest structural part used to date at Chance Vought weighs 78 lb and the smallest 3½ oz (Fig. 7). Certainly there can be many problems associated with heat-treating parts such as the larger of the two. The heat-treatment actually used is:

1. Normalize stock or rough machined parts at slightly higher temperature than used in normal practice.
2. Austenitize at slightly lower temperature than that customarily used.
3. Quench in circulated — not agitated — oil at 160–180 F.
4. Temper at 400–450 F for 4 hr minimum.
5. Strip copper plate, if used. Bake at 375 F for 4 hr.

The atmosphere used during heat-treatment of copper-plated parts must be slightly carburizing to the base metal. A strong oxidizing atmosphere converts the copper plate to oxide, and decarburization results. Too strong a carburizing atmosphere may actually carburize the base metal in spots where the atmosphere finds voids in the copper plate. These localized spots of carburized steel act as strong stress raisers, and full ductility cannot be developed.

There may be serious distortion problems in heat-treating a part such as the 78-lb one. This part gave us a great amount of trouble due to distortion. But by studying the part and its distortion tendencies very carefully, it was possible to devise a procedure

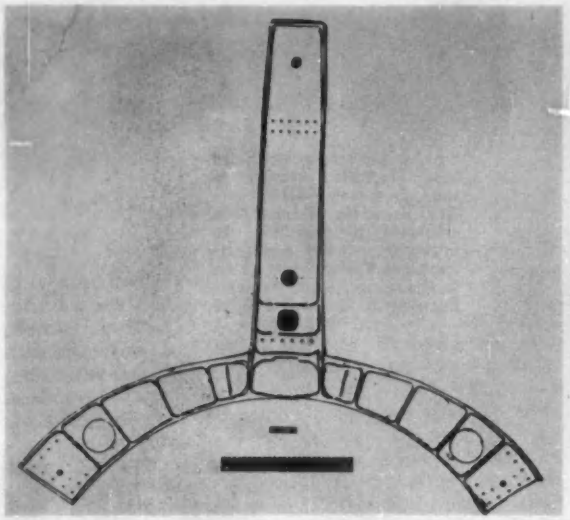


Fig. 7 — Largest structural component at Rockwell C50-53 used to date by Chance Vought weighs 78 lb. Smallest one weighs 3½ oz. Both are shown with 1-ft rule.

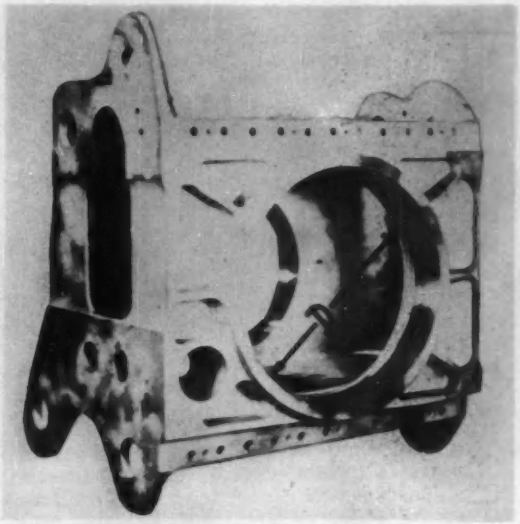


Fig. 8 — Bearing housing is made of SAE 4340 steel heat-treated to Rockwell C50-53. Tolerance on bearing cavity marked "D" is +0, - 0.0005 in.

The Processing of Wrought Steel to High Strength

continued

whereby this part is held within ± 0.010 in. on practically all dimensions. The secret of success here was "creep-forming."

By this is meant that the part is tempered in a closely controlled fixture and is caused to assume the shape dictated by the fixture during one cycle of 16 hr of tempering at 400–450 F.

There is, of course, the possibility of retaining austenite due to the severe quench and low tempering temperature. But careful studies using x-ray diffraction methods showed an average of 7% retained austenite after the specified heat-treatment; 5½% average after 24 hr of heating at 250 F; and none after either tempering at 500 F, tempering at 400 F for 125 hr, or after cold-treating at – 100 F immediately after the quench.

Even though the austenite retained may transform under load, the small amount available for transformation to untempered martensite during use is not believed to be significant with respect to resulting embrittlement. For the majority of such parts no special precautions are taken. Only those parts with extremely close tolerance on large dimensions have given trouble.

Fig. 8 shows a bearing housing which gave us considerable trouble in producing the cavity for containing the bearing. There are two of these parts per airplane. The arrows indicate that dimension, roughly 6 in., which is held to + 0, – 0.0005 in. In conventional practice this part would have this dimension generated by grinding. In this instance, since stress-relief after grinding was required, it became evident that the thermal treatment was causing the part to go egg-shaped. It was suspected that localized transformation of retained austenite was at fault.

Two procedures were found to be necessary in keeping this part round. The first was to remove a very slight amount of metal by grinding followed by stress-relieving at 350 F, repeating this treatment until the dimension was in tolerance. The second procedure involved austenitizing in a neutral salt bath, quenching in oil, degreasing, transforming the austenite at – 100 F, and tempering at 400 F for 4 hr. The latter procedure allowed finish grinding with significantly fewer passes and only one final stress-relief cycle.

Results of both treatments indicate that transformation of retained austenite was causing the trouble.

Any discussion of heat-treating high-strength steel is incomplete without a warning to stress relieve after every machining or grinding operation performed on the part at full hardness. Failure to stress relieve may cause cracking in subsequent processing operations. Early experience with this material included numerous instances of parts cracking during the cadmium-plating operation. Each of these was successfully resolved by incorporating the stress-relief immediately after finish machining or grinding.

Finishing

Currently parts are finished in a special metallic paint. Although this paint is usually considered inadequate for corrosion prevention, no instances of corrosion have been observed to date, except on those parts subjected to abnormal service abuse. The mico-aluminum paint is applied quite heavily.

To Order Paper No. 82B . . .
. . . on which this article is based, turn to page 6.

New Headaches for High–Compression Engines

Starting noises and stalling, and after-running are three problems that are intensified in high compression ratio engines. Starting noise may boost octane-number requirements still higher, while stall during cranking and after-running may have the engineers talking about the cetane quality of gasoline.

Based on paper by

V. F. Massa

Esso Research and Engineering Co.

THREE engine starting and stopping problems will become more intense as compression ratios climb in modern passenger-car engines. The problems are: hot-starting noise, hot-cranking difficulty, and after-running. All three occur in the 50–500 rpm range.

Hot-starting noise is defined as engine detonation during the cranking period. The detonation severity is primarily a function of research and motor octane number, fuel volatility and to a lesser extent, aromatic content of the fuel.

Hot-cranking difficulty is a slowing down or stalling of the engine during the cranking period. It is caused by early compression ignition of the fuel. The cetane quality of the gasoline has a major effect on this problem.

After-running is compression ignition in the cylinders after the ignition key is turned off. It is not run-on resulting from surface ignition due to deposits or hot spots. After-running also depends largely on the cetane quality of the fuel.

In all three starting or stopping problem cases, paraffinic-type fuels increased the combustion difficulties. This is just the reverse of tests run to find the effect of fuel type on high-speed-engine rumble noises. (The rumble results were presented in other papers at the technical session.)

Hot-Starting Noise Test Results

Tests on 38 late-model cars show a rapidly increasing octane-number requirement as the compression ratio goes up. Around a compression ratio range of 8/1–10/1, the hot-starting noise requirement surpasses the normal road antiknock demand for high-octane-number fuel. This is shown in Fig. 1.

Other factors that influence hot-starting noise are:

· Engine (water jacket) temperature. Running tests after a car was warmed up produced much more engine noise. Also increasing the water jacket

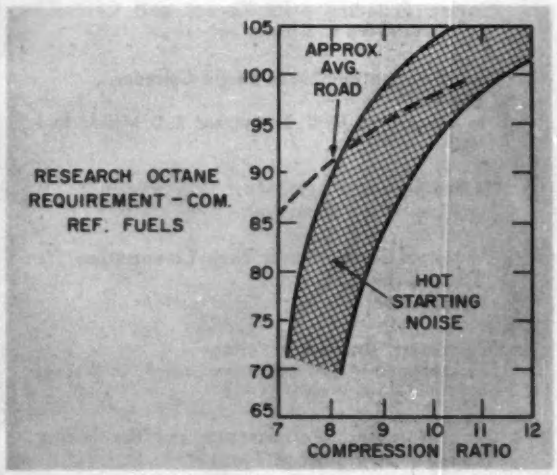


Fig. 1 — Hot-starting noise may be a more severe octane-number requirement than road knock. Tests on 38 late-model cars show steeply increasing octane requirements as compression ratio increases. After a 10/1 compression ratio, the hot-starting requirements exceeded the road knock rating. Although starting noise isn't now a serious problem, it may become one as compression ratios increase.

New Headaches for High–Compression Engines

. . . continued

THIS paper is one of a series given on engine noise at the 1958 SAE Summer and National Fuels and Lubricants Meetings. It may be obtained separately as paper No. 61B or as part of a special publication (SP-157 — Price: $4.50 to members; $7.00 to nonmembers) containing all the "noise" papers. Other papers in SP-157 are:

"Thudding in High Compression Ratio Engines"
by W. E. Morris and D. C. Farriss, E. I. du Pont de Nemours & Co. (61C)

"Rumble — A Deposit Effect at High Compression Ratios"
by A. E. Felt, J. A. Warren, and C. A. Hall, Ethyl Corp. (61D)

"Knock, Knock — Spark Knock, Wild Ping or Rumble?"
by R. H. Perry, Jr., and H. V. Lowther, Socony Mobil Oil Co., Inc. (61E)

"Knock, Rumble, and Ping"
by H. F. Hostetler and W. R. Tuuri, Standard Oil Co. (Ohio) (61F)

"Engine Pounding — Its Causes and Control"
by J. L. Bame and R. G. Tuell, Shell Oil Co. (61G)

"Investigating Rumble in Single-Cylinder Engines"
by J. A. Robison, M. D. Behrens, and R. G. Mosher, Ford Motor Co. (61H)

"If You Squeeze Them, Must They Scream?"
by W. M. Wiese, General Motors Corp. (61J)

"Abnormal Combustion in High-Compression Single-Cylinder Engines"
by R. W. Young, Continental Oil Co. (105A)

"Customers' Antiknock Ratings"
by Lamont Eltinge, H. R. Taliaferro, and T. O. Wagner, Standard Oil Co. (Indiana) (105B)

"Road Antiknock Performance and the Boiling Range of Hydrocarbon Types"
by F. D. Buersteta and W. C. Healy, Jr., Ethyl Corp.; and L. A. McReynolds, H. C. Walters, and Raymond Rohde, Phillips Petroleum Co. (105C)

temperature from 130 to 180 F increased the octane-number requirement from 89 to 101.

· Ignition timing. Retarding ignition timing was beneficial as long as the noise (detonation) occurred after the spark. When compression ignition caused the noise, spark timing had no effect. Some fuel types accentuated the effects of spark timing.

· Engine cranking speed. High-speed cranking reduced starting noise.

· Fuel type. Paraffinic-type fuels give the most noise, as seen in the cycle analysis shown in Fig. 2. Tel did not have any effect on noise level when it was used to obtain desired octane levels. An equation that gives hot-starting octane number in terms of primary reference fuels is:

$$\text{Hot-starting noise O.N.} = 1.036\ (\text{Res. O.N.}) - 0.306\ (\text{Motor O.N.}) - 0.041\ (90\%\ \text{pt. F}) - 0.033\ (10\%\ \text{pt. F}) + 0.040\ (\%\ \text{Aromatics}) + 42.5$$

Combustion-chamber deposits did not have a noticeable effect on hot-starting noise.

Cetane Number Measures Hot-Cranking Problem

As compression ratio goes up, a cranking engine will have compression ignition if the centane number of the gas is too high. This compression ignition happens btc and tends to stall the engine.

To measure starting difficulty a Hot-Cranking Index was developed. This index is defined as:

$$\text{Hot-Cranking Index} = \frac{\text{Maximum rpm reached during cranking}}{\text{Minimum rpm reached during cranking}}$$

Its significance is that a fuel that allows compression ignition will either speed up or slow down the engine, depending on when the ignition takes place. Therefore, large differences in rpm during cranking shows up as a high index number, indicating a poor fuel.

An example of this relationship is shown in Fig. 3. Here, a special cetane measurement had to be devised since the fuels tested were out of the normal cetane test scale. The ASTM-CFR cetane engine was operated at the minimum compression ratio that would give steady running.

After-Running

After-running is also a compression-ignition phenomenon. It therefore depends on the cetane number of the fuel used. Paraffinic fuels turned out to be the most susceptible to after-running, as shown in Fig. 4.

Deposit ignition was eliminated as a cause of after-running in the tests because:

· Increased engine speed eliminated combustion.

· Measured spark-plug-tip temperatures were well below the temperature needed for hot-spot ignition.

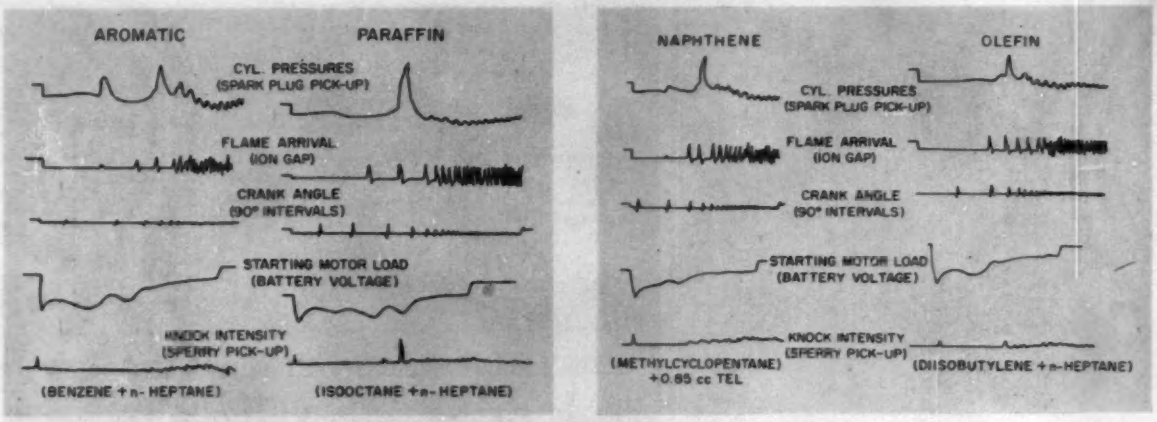


Fig. 2 — Type of fuel has a marked effect on hot-starting noise. Of four types tested, paraffinic fuel produced the strongest knock (bottom line of engine cycle plots). All fuels had a research octane number of 98.

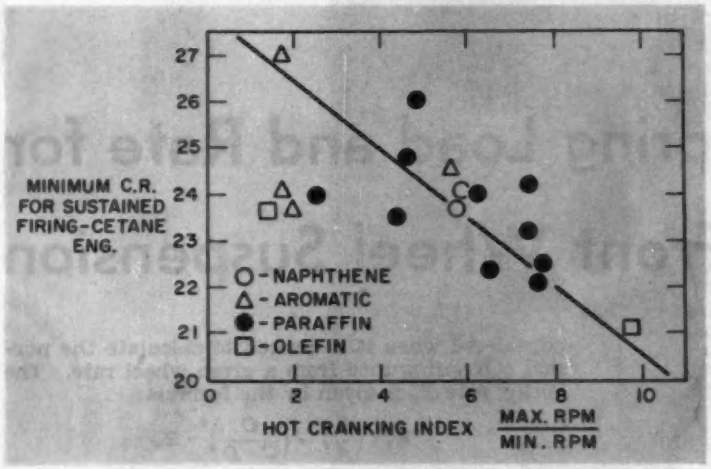


Fig. 3 — Hot-cranking difficulty is related to fuel cetane quality. Compression ignition can slow or stall a cranking engine. A measure of cranking difficulty is the Hot-Cranking Index (difficulty increases with high index numbers). The HCI is plotted against a special cetane scale. The scale gives the minimum compression ratio that will sustain dieseling in the ASTM-CFR cetane engine.

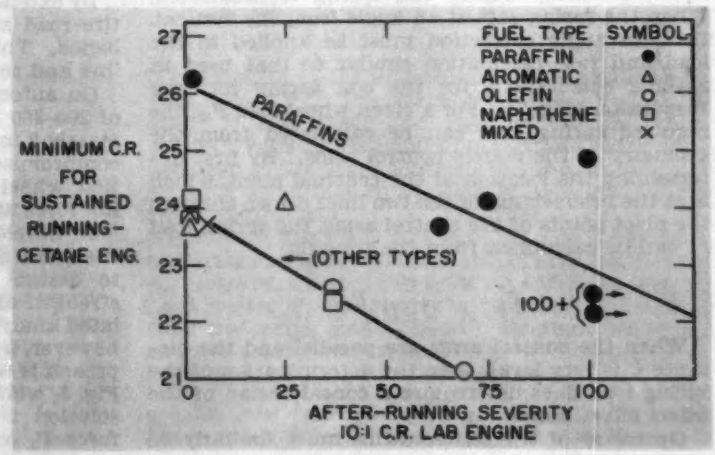


Fig. 4 — Paraffinic-type fuel promotes after-running in high-compression engines. This is because after-running is due to compression ignition.

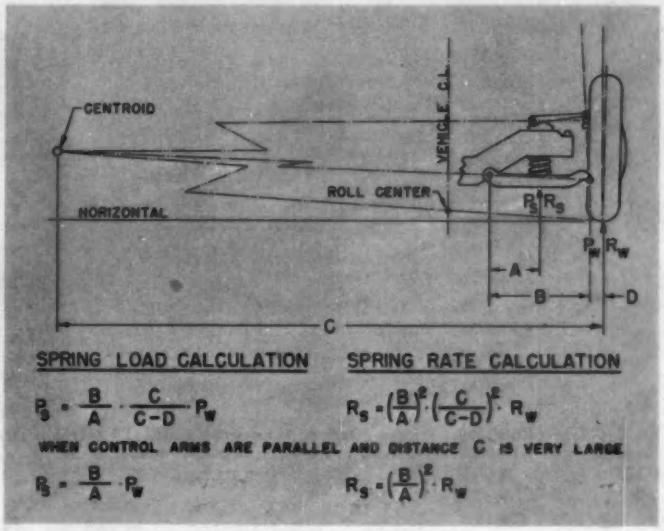


Fig. 1 — Calculation for normal coil spring load and rate for independent front wheel suspension.

How to calculate:

Normal Spring Load and Rate for Independent Front Wheel Suspension

Excerpts from paper by

Michael C. Turkish

Spring Division, Eaton Mfg. Co.

THE method of calculating the normal coil spring load and rate required for independent front wheel suspension is outlined in Fig. 1. For simplicity, a vertically acting coil spring is illustrated. When the spring acts at an angle from the vertical, then an angle correction must be applied to the load and rate calculation similar to that used in making calculations for the coil spring for rear suspension (Fig. 2). For a given wheel load P_W, the required spring load can be calculated from the geometry of the double control arms. By first determining the location of the centroid point, which is at the intersection of the two lines drawn through the pivot points of the control arms, the spring load P_S can be calculated from the formula:

$$P_S = \frac{B}{A} \cdot \frac{C}{C-D} \cdot P_W$$

When the control arms are parallel and the distance C is very large, then the determination of the spring load does not require a consideration of the wheel offset dimension D.

Geometry of the control arms must similarly be considered when it is desired to calculate the normal coil spring rate from a given wheel rate. The spring rate R_S is given by the formula:

$$R_S = \left(\frac{B}{A}\right)^2 \cdot \left(\frac{C}{C-D}\right)^2 \cdot R_W$$

and this also simplifies when the control arms are parallel and distance C is very large, as shown in Fig. 1.

By extending a line from the centroid point to the tire-road surface, the roll center is readily established. This is at the intersection of the reference line and the vehicle vertical line.

On automotive-type vehicles, a centroid distance of 200–300 in. with a roll center height of approximately 2 in. above the road appears to give the best compromise in the various factors of tread variation, wheel tilt, roll center height, and high cornering force at the tire-road surface.

In developing an independent wheel suspension, the loads in the control arms must be determined to design these members properly for adequate strength and rigidity. These forces can be calculated analytically for various positions of the wheel; however, a much more rapid and very accurate approach is to employ the graphical method shown in Fig. 3, which was developed by W. D. Allison. The solution is begun by determining the downward force P_J on the lower ball joint at normal wheel

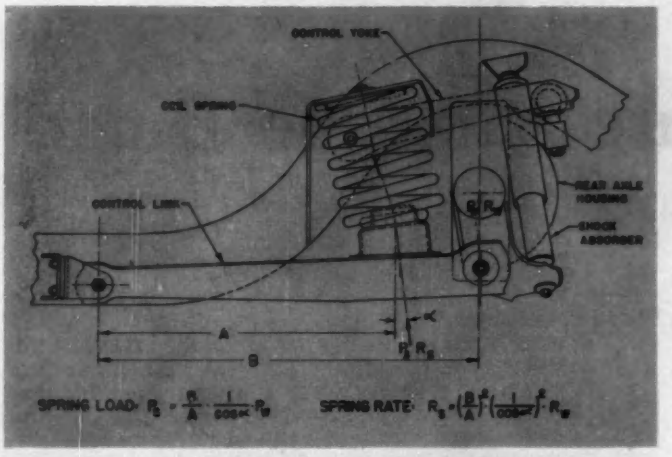


Fig. 2 — Calculation for normal coil spring load and rate for rear suspension.

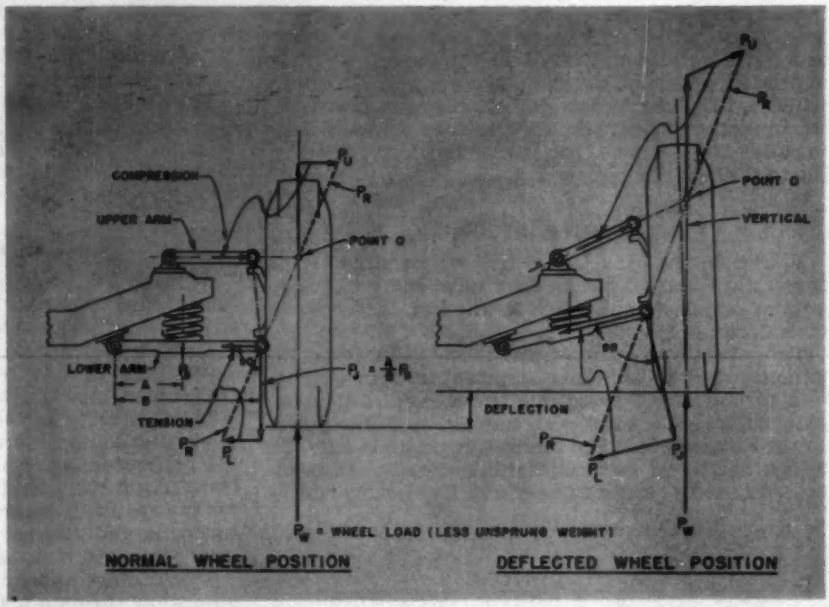


Fig. 3 — Graphical determination of loads in structure of independent front wheel suspension.

position, which is calculated from the spring load to be equal to:

$$P_J = \frac{A}{B} \cdot P_S$$

Point 0 is then established at the intersection of a line through the pivot points of the upper control arm and a vertical line through the center of the tire-road contact surface. A reference line is then drawn through point 0 and the lower ball joint. Vector P_L is then drawn parallel to the lower control arm to the intersection of the reference line previously drawn. This establishes the magnitude of vector P_R, which is drawn as a dashed line on the layout. Vector P_R is then laid out from point 0 along the reference line. The vector P_U is then drawn parallel to the upper arm, and its magnitude is established by the intersection of the vertical line with vector P_U. The vertical component of P_R is equal to the wheel load P_W, less the unsprung weight. Vector P_L is equal in magnitude to the tension load in the lower control arm, and vector P_U is equal in magnitude to the compression load in the upper control arm.

Similarly, the loads in the upper and lower control arms can be determined graphically for various positions of wheel deflection, as shown in Fig. 3. Load vector P_J is determined first by calculation from the spring load as before, resultant vector P_R is then established, from which the control arm loads P_L and P_U are readily determined.

To Order Paper No. 51C . . .
. . . on which this article is based, turn to page 6.

Turbocharged Diesel

Based on paper by

W. J. Lux

Caterpillar Tractor Co.

ONE of the disadvantages often mentioned against the turbocharged engine for vehicle application is that it is said to have a slow response to changes in load. Actually, its response to load change is not much different from that of an equivalent naturally aspirated engine of the same horsepower. It is only when a turbocharged engine is compared with its unsupercharged version having less power — as is usually done — that the turbocharged engine is likely to show the greater lag.

Inertia Effect

It is true that the lag of the turbocharger rotor speed during acceleration may have some effect on engine response, but there is another factor to be considered — inertia.

Table 1 shows a comparison of various inertia components and the total inertia values for four engines — a turbocharged diesel and three designs of naturally aspirated engine — all having the same power at the same speed. The inline-8 engine has only the added inertia of two more crank throws. It is assumed that the same damper and flywheel would be used. This results in a 7% increase in inertia. The V-8 has a completely different crank structure, which will probably require a larger torsional damper of a different type. If it is assumed that the same flywheel is used, there is still a 33% increase in inertia over the 6-cyl turbocharged engine. Changes in bore and stroke to obtain a 6-cyl engine with 33% more displacement (to give the 33% more power that it is assumed the turbocharged engine will give over its naturally aspirated version) results in about 11% increase in inertia.

More inertia means, very simply, slower engine acceleration or less response. Design details may be changed or refined to obtain lower inertia on a given model, but turbocharging will give added horsepower with no added rotational inertia.

table 1—engine inertia comparison (WR^2 measured in lb-in.-sec^2)

	Engine WR^2	Damper WR^2	Flywheel WR^2	Total WR^2	% Increase
6-Cyl 4.5 × 5 Turbocharged Engine	3.0	1.2	11.0	15.2	...
8-Cyl 4.5 × 5 Naturally Aspirated Engine	4.0	1.2	11.0	16.2	7
V-8 4.5 × 5 Naturally Aspirated Engine	7.2	2.1	11.0	20.3	33
6-Cyl 4.95 × 5.5 Naturally Aspirated Engine	4.2	1.4	11.0	16.8	11

Test Data

Actually, very little difference in response was found when a turbocharged engine was compared with the naturally aspirated version of the same engine, both operating a diesel-electric generator set.

Fig. 1 shows the effect, first, of removing the generator load, and then of suddenly returning the full load to the set — for both types of engine. The same governing equipment was installed in both cases and the generators were of very similar design. In this comparison 100% load was used for each set — 60 kw for the naturally aspirated engine and 100 kw for the turbocharged engine. This put the engines on a good comparison basis.

Two factors appear. First, the turbocharged engine went through a somewhat larger speed change during the transient period. Second, it recovered slightly faster than the naturally aspirated engine when the load was removed and slightly slower when load was applied. These differences were small enough to be neglected, as they represented the combined effects of governor setting variations, engine variation, differences in generator inertias, and differences between the transient load conditions of the generators at their respective power levels.

Fig. 2 shows how these two units reacted under similar loads. In this case the naturally aspirated set carried a 60-kw load (100%) and the turbocharged unit carried a 56-kw load (56%). Here the turbocharged engine had a lower speed change, probably because of the higher inertia of its generator, and about the same recovery time. Variation from run to run showed that the time difference obtained was not significant.

To Order Paper No. 75A . . .
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Responds OK to Load Change

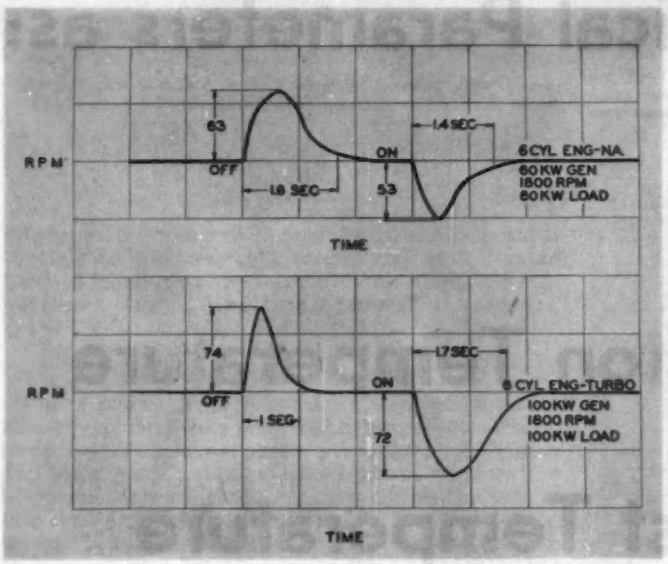


Fig. 1 — Engine response comparison for turbocharged engine and naturally aspirated engine. Both engines were 6-cyl, 4½ × 5½ units. Note that the turbocharged engine goes through a somewhat larger speed change during the transient period. The turbocharged engine recovered slightly faster than the naturally aspirated engine when the load was removed and slightly slower when load was applied.

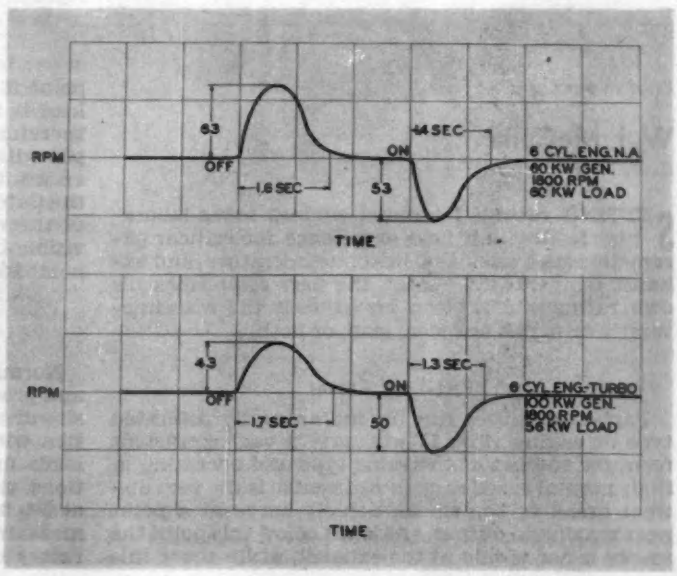


Fig. 2 — Engine response comparison for the units described in Fig. 1, but with naturally aspirated engine carrying 60 kw or 100% load and turbocharged engine carrying 56 kw or 56% load. Here the turbocharged engine had a lower speed change, probably because of the higher inertia of its generator, and about the same recovery time.

Rating of Diesels Depends on Such Critical Parameters as:

- Smoke
- Piston Temperature
- Exhaust Temperature

Based on paper by

W. J. McCulla
Caterpillar Tractor Co.

SETTING ratings for diesel engines takes laboratory testing and field experience for critical parameters such as smoke, piston temperature, and exhaust temperature. Later, the user establishes his own rating which often far exceeds the manufacturer's rating as to speed, load, or both.

Part-Load Curves

Part-load curves run on the naturally aspirated type of engine (Fig. 1) will have a very consistent form for engines of the same type and operating in their normal speed range. Noticeable is the very distinct break in the smoke density curve at a point near maximum output. At loads below this point the smoke is not visible in the exhaust, while above this point it grows denser with rapidity until maximum load is reached. This type of engine can operate, therefore, comparatively close to its maximum output with a smoke-free exhaust. Thus, if we select an arbitrary value of smoke density such as 0.3 on the Caterpillar smoke meter, a point beyond the knee of the curve where the smoke is becoming clearly visible in the exhaust, it becomes a useful starting point for selecting ratings.

Rating on a Smoke Basis

Normal atmospheric variations of temperature and pressure can cause changes in atmospheric density of up to about 8%. Therefore, to avoid operation with objectionable smoke at rated speeds and loads under normal variations of ambient conditions, the intermittent rating is tentatively selected at 8% below the load at which 0.3 smoke appears as measured on the smokemeter under standard laboratory conditions of 29.6 in. of mercury and 90 F.

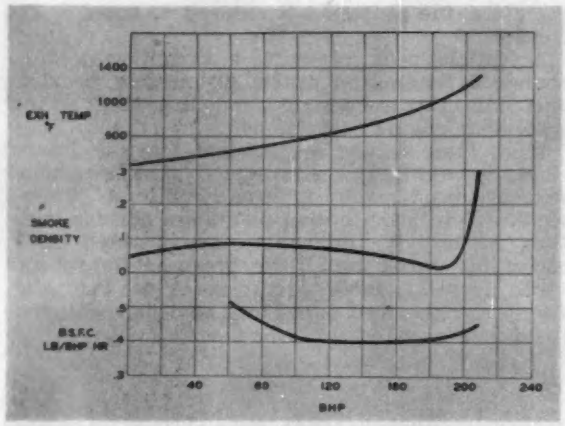


Fig. 1 — Typical part-load curve of naturally aspirated diesel engine. Note sharp break in smoke density curve near point of maximum output.

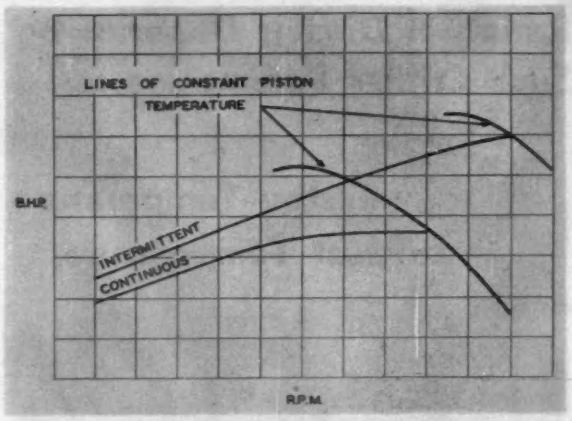


Fig. 2 — Lines of constant piston temperature plotted over a proposed rating curve. Any point to the left of the constant temperature line constitutes a safe continuous rating.

The tentative rating of 92% of the 0.3 smoke point is checked to see that 10% torque rise at 2/3 rated speed is possible at any selected point along the rating curve. If not, the rating is reduced as needed.

Effect of Piston Temperature

Fig. 2 shows some constant piston temperature lines overplotted on a proposed rating curve. Piston temperature affects deposits, wear, and ring sticking and since there is a point where piston temperature begins to increase rapidly, any point to the left of this constant temperature line is a safe continuous rating. Similarly a higher piston temperature can be selected as a limiting value for an intermittent rating where strength and fatigue life for the piston are still adequate to meet the greater loads. On either rating curve the piston becomes cooler as speed is reduced. The continuous curve could even blend with the intermittent at lower speeds with a safe margin of piston temperature.

A curve of constant exhaust temperature shows a trend similar to that of piston temperature although less pronounced. It is the shape of the exhaust temperature curve that prevents raising the continuous curve to match the intermittent at lower speeds. Exhaust temperature is not as limiting as piston temperature because valve materials and facings will function at present exhaust temperatures. However, a value can be selected which is reasonable for the materials chosen. Then operation below this particular curve is acceptable from the standpoint of exhaust temperature.

Other Factors in Rating

The rate at which heat is released in the cylinder obviously has a definite effect on the temperatures of the various parts of the combustion system. For that reason a plot of constant fuel rate in lb per hr per cu in. displacement of the cylinder is another useful line limiting operation. Since fuel rate is closely related to thermal loading, the fuel rate and,

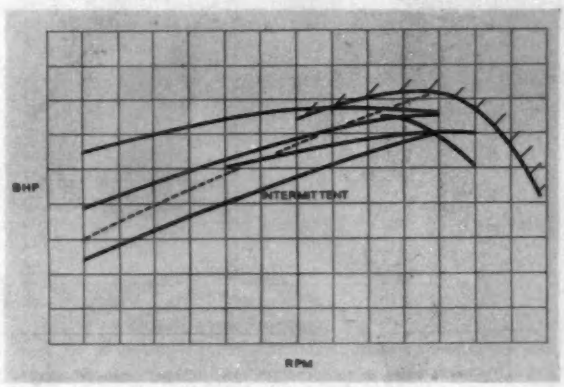


Fig. 3 — Combining all limiting factors in a single curve shows rating curves to be well circumscribed by the limiting conditions.

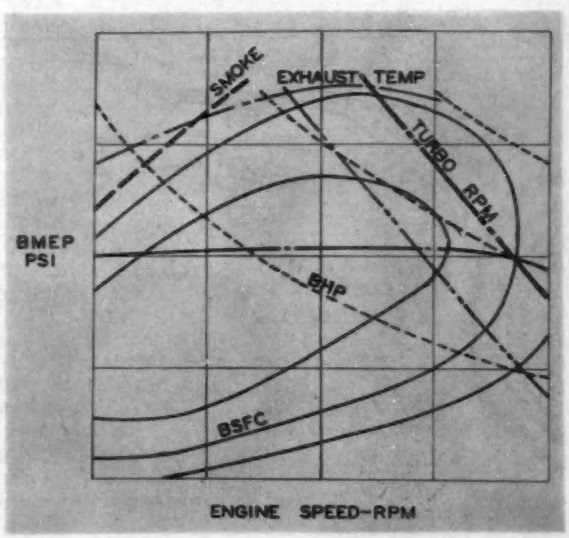


Fig. 4 — Part-load curves in composite form show turbocharger speed to be a factor for consideration. These are constant value lines.

Rating of Diesels Depends on Such Critical Parameters as:

- Smoke
- Piston Temperature
- Exhaust Temperature

continued

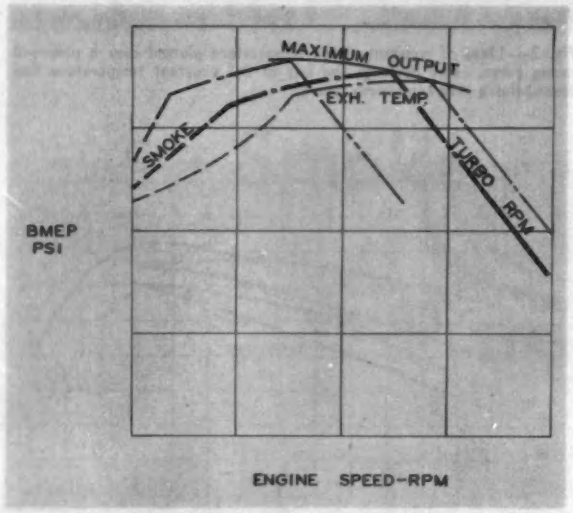


Fig. 5 — Umbrella curve of turbocharger rpm, exhaust temperature, and exhaust smoke taken from Fig. 4 and plotted by itself, together with similar curves for two other nozzle sizes. This gives performance limits with three turbine nozzles.

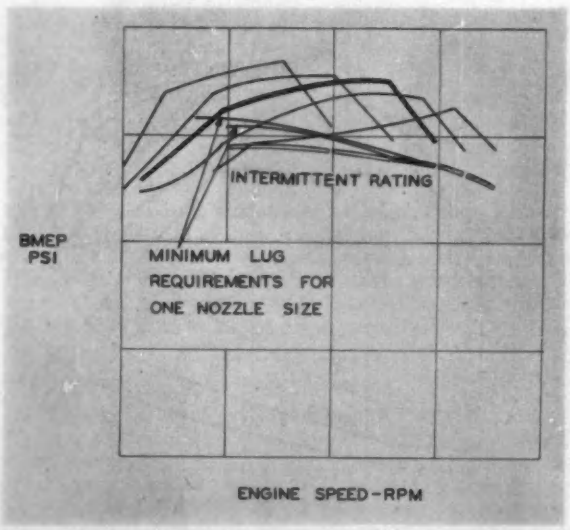


Fig. 6 — Lug performance of turbocharged diesel engine from intermittent ratings.

therefore, the heat load is reduced as speed is increased.

Acceptible peak pressure, although subject to change depending on piston, piston ring, bearing, and connecting rod design, is a definite limit at any stage of an engine's development.

If all these factors are brought together into a single curve (Fig. 3), the rating curves are seen to be well circumscribed by limiting conditions. Intersection of various limiting points are obvious locations for test. If test engines are operated under conditions worse than those proposed for ratings (both for safety factor and to accelerate the test), an increase in speed at full load obviously will offer the most promise.

Rating of Turbocharged Engines

Other limits become significant in the case of turbocharged engines. Fig. 4 presents plots of part-load curves in a composite form showing the addition of turbocharger speed as an item for consideration. Manufacturers of turbochargers specify certain limits expressed as rotational speed, exhaust temperature and, in some cases, surge of the compressor. At times exhaust smoke becomes a limit at a lower bmep than does surge and so becomes the controlling factor. This grid of curves is characteristic of an engine with a single fixed nozzle in the turbocharger. A change of nozzles to favor operation at another speed in effect makes this engine an entirely different one.

Umbrella Curve for Turbocharger Variables

If the so-called umbrella curve of turbocharger rpm, exhaust temperature, and exhaust smoke or surge is lifted from Fig. 4 and plotted by itself, we get Fig. 5. From other tests are added umbrellas depicting operation with two additional nozzle sizes. Then, by connecting the points of intersection of exhaust temperature and turbocharger rpm or, as in the case of some boundary matching conditions, exhaust smoke or surge and turbocharger rpm, a line can be plotted representing maximum output of the engine at these limiting points. Obviously, to operate on every point along this curve would require either an infinite variety of nozzles or a continuously variable nozzle, neither of which appears practical at present.

Ratings for the engine with free-running turbocharger therefore must be chosen within the bounds of a practical number of fixed nozzles. At any rated engine speed the turbocharger speed must be within limits. During lug from any rating the exhaust temperature or smoke must be within reason. The dark lines in Fig. 6 represent the umbrella curve of a representative nozzle and the section of the intermittent curve where this nozzle is applicable. A similar relationship can be seen to exist for the other umbrella curves and the associated segments of the intermittent rating curve.

To Order Paper No. 64A . . .
. . . on which this article is based, turn to page 6.

In the reception room before the banquet were Ellis Spackman (left) and L. A. Lesovsky (right). Spackman, guest speaker at the banquet, discussed the importance of Egypt and North Africa to the United States in his speech, "West of Suez." Lesovsky was banquet chairman.

Admiring plaque given in commemoration of his outstanding job as General Chairman of the Meeting is Gilbert Way (left), Technical Representative, Western Region, Ethyl Corp. Presenting the award to Way is Joseph Gilbert (right), assistant to the general manager of SAE.

West Coast Meeting Discusses:

Fuels, Powerplants, and Heavy-Duty Equipment

THE SAE National West Coast Meeting, August, 11–14 at the Ambassador Hotel in Los Angeles, gave comprehensive coverage to all facets of heavy-duty equipment operation.

With over 400 members and guests present, such topics as heavy-duty brakes and tires, heavy-duty construction equipment, powerplants, test facilities, heavy-duty automotive equipment, and requirements for automotive fuels were discussed at the Meeting.

Better than 250 engineers attended the banquet at which Ellis W. Spackman, Chairman, Social Sciences, San Bernardino Valley College spoke on "West of Suez."

Approximately 80 of those attending the Meeting hopped three planes to the Yuma Test Station to observe a U.S. Army Ordnance Desert Test Activity demonstration of ordnance automotive equipment.

Programs for the 6 technical sessions were planned by a committee headed by General Chairman Gilbert Way, Technical Representative, Western Region, Ethyl Corp.

Technical session chairmen were: John Conti, City Motor Co., L. A. Somers, Shepherd Machinery Co., E. R. Donner, Standard Oil Co. of California, C. A. Hancock, Shell Oil Co., D. F. Pennell, Canadian Kenworth, Ltd., and Nicholas Buchanan, General Petroleum Corp.

Toastmaster at the banquet was R. Wayne Goodale, Manager, Lubrication Division, Standard Oil Co. of California and Vice-President representing SAE Fuels and Lubricants Activity.

Capsule reports of all six technical sessions at the Meeting appear on the next two pages.

Capsule reports of all 6 technical sessions at the SAE National

Monday

HEAVY-DUTY BRAKES AND TIRES — Brakes and braking systems are on the ragged edge of inadequacy. The basic design of brakes has remained the same for a quarter-century, while average loads and speeds have increased.

"Our present internally expanding brake is trying to rupture the brake drum from the very first minute it is put into service." If the present brake resists improvement, then it will be necessary to reduce its work load with retarders or other means.

Steady application of brakes at lower pressures in descending long grades will add to brake life. The theory of intermittent application to give brake drums a chance to cool not only doesn't work, but too frequent brake application can deplete air supply to dangerous levels. (Paper 69A)

Acceptance by the transportation industry of some unit of standard friction value for brake linings would simplify brake evaluation, lead to better operating efficiency, and result in greater safety. (Paper 69C)

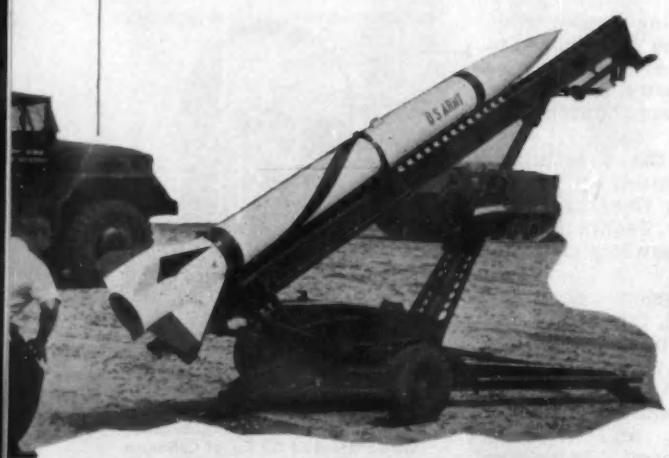
The truck tire of the future will very likely have skinned-down racing-type construction, make use of the latest in synthetics, have a greater number of plies and higher inflation pressures, and be tubeless. These changes will come about because of increases in truck horsepower and higher operating speeds.

Dissipation of heat generated by uninterrupted, high-speed, turnpike travel can be accomplished by going part way in the direction of thinner treads and offsetting the reduction in material by using more durable tread compounds or resorting to more frequent retreading. Portable equipment which will retread a tire without removal from the rim is a distinct possibility.

Advances in synthetics, exampled by coral rubber which surpasses natural rubber, suggest the possibility of tailoring tires with chemically produced materials. Imagine a tire with synthetic tread having vastly improved abrasion and cracking resistance, its body made of rubber designed especially to provide low running temperature and maximum adhesion and resistance to separation and aging. The tubeless interliner will be made of another synthetic impermeable to air and with a plasticity capable of sealing punctures. (Paper 69B)

HEAVY CONSTRUCTION EQUIPMENT — Estimating the cost of construction is complicated by a constantly changing economy. Cost histories, however, should help keep estimates "in the ball park". As the economy shifts, adjustments should be made in cost figures and in judgment. (Paper 70A)

Rippers offer an economical method for the size reduction of rocks so that the resulting material can be rehandled or loaded. Selecting the proper ripper point for the job, however, requires careful consid-



SAE members inspected Little John missile at Yuma Test Station. Eighty field-trippers watched the U.S. Army Ordnance Desert Test Activity demonstrate ordnance automotive equipment.

Wednesday

HEAVY-DUTY AUTOMOTIVE EQUIPMENT — Engineers are planning to make trucks easier to handle and more capable of benefiting by the new highway program.

More foolproof miles need to be designed into truck transmissions and causes of trouble and annoyance removed. Limited access highways with minimum grades and favorable traffic conditions, plus more powerful engines with flatter torque curves, can simplify transmission design, reduce the number of speeds, and make operation easier for the driver. Automatic or semi-automatic transmissions and power shifting will give future drivers assistance in making gear changes, thereby increasing the productivity of the vehicles. (Paper 73E)

Air suspension is indicated for future trucks and trailers. "The proved ability of air as the suspension medium for motor coaches to improve vehicular riding qualities, reduce maintenance, and reduce transmissibility of shock and noise must certainly lead to the conclusion that the same advantages can be obtained in truck and trailer installations." (Paper 73A)

The Teracruzer is currently being tested by the

eration of the type of material to be ripped, the desired size of the fragments, the material destination, and the means of transportation. (Paper 70B)

With the increased performance demands of off-the-road tires, every means must be used to reduce tire temperature. Part of this can be accomplished by the development of compounds that will build up less heat. This type of compound must be incorporated in our standard tires to as great a degree as possible, but it must be realized that there are limitations as to the degree that this can be accomplished by compounding alone. The standard heavy construction tire must always be compounded to withstand the roughest type of service with heat resistance a secondary consideration. This seems to indicate the development of a line of specially compounded and specially designed thinner and lighter tires made primarily for heat resistance. Then, with the existence of heavy tread tires, standard tread tires, and thin heat-resistant tires, the selection of the proper tire for each individual job becomes of the utmost importance. (Paper 70C)

Hydrotarders are being applied to commercial motor vehicles to relieve wheel brakes of all service except actually stopping vehicles. Numerous installations demonstrate the possibility of hauling heavier loads on longer and steeper grades with complete safety, and have revealed such gains as longer tire life despite faster schedules. (Paper 70D)

Tuesday

POWERPLANTS — Research on diesel, free-piston, and gas turbine engines is advancing at a rapid pace. "The diesel has not yet exhausted its potential for development and it will only be supplanted by a new engine if it occupies less space, weighs less, and is more economical to operate." Also, any such new engine would have to be cheaper to produce and maintain and give better performance.

The gas turbine is here in a competitive form and shows promise in the size range beyond the diesel. Other powerplants show little promise for the near future. (Paper 71A)

The turbodiesel engine, constantly being improved, has such attributes as low cost, small size, light weight, high specific output, high efficiency, durability, and dependability. While the gas turbine and free-piston engines may be regarded by many as having a bright future, difficult engineering problems remain to be solved, among them simplicity and fuel economy. (Paper 71B)

For best results, turbochargers must be properly matched to high-speed diesel engines. Considerations include: the type of service for which the engine will be used; the ambient temperatures and pressures to which the engine will be exposed during operation; and, the type of control system which will be used for both the engine and the turbocharger. (Paper 71C)

NEW RESEARCH FACILITIES — Gulf, Pure Oil, Union Oil, California Research, Shell, and Chevrolet have new facilities for testing motor vehicles, fuels, and oils. Through the use of dynamometers and other laboratory equipment, accuracy and speed of testing are much better than that obtainable on the open road. "Possibly best of all, there is not the constant strain of avoiding a traffic accident." (Papers 72A, 72B, 72C, 72D, 72E, and 72F)

U. S. Air Force for use in ground support of the Matador guided missile. Mounted on soft tires 42 in. in diameter and 50 in. long, this off-the-road vehicle has proved to be capable of negotiating grades, snow, and soft sand in which other vehicles become immobilized. The Teracruzer can travel paved roads at 45 mph and climb even roadless 60% grades. (Paper 73C)

REQUIREMENTS FOR AUTOMOTIVE FUELS — Realistic commercial diesel fuel specifications are needed. And they can be developed if engine builders reduce the number of divergent fuel requirements and if the petroleum industry curtails the present permissible practice of excessive dual branding.

At the present time, 41 diesel engine builders have 39 differing fuel specifications. And as for dual branding, 70% of Grade 1-D diesel fuels may be classified as Grade 2-D, and 100% of the No. 1 burner fuels may be designated as No. 2 fuels. Morever, instead of tabulating diesel fuels by ASTM grades, as in the past, they are now listed under so-called classes of service for which the fuels are recommended by the petroleum manufacturers, which are meaningless to the consumer. (Paper 74A)

Thermal efficiency peaked at 17/1 compression ratio in seven 324 cu in. V-8 engines tested recently by Ford engineers . . . and the decrease in efficiency at higher compression ratios was shown to be due primarily to delay in completion of the combustion process.

These were the chief results of a study aimed at finding out how recent progress in both engine and fuel design may have affected the relationship between compression ratios and engine efficiency.

The results confirm the idea that substantial gains in thermal efficiency still can be achieved by further increases in compression ratio . . . if petroleum technology finds a way to produce economically still higher octane fuels. (Paper 61A)

The most miles for the dollar come from the car that uses 97-octane-number fuel, present calculations show. This is the point at which increased efficiency from high compression ratios runs into the rising cost of high octane fuel. Unless there is a substantial improvement in the manufacturing processes of gasoline — or a radical change in engine design — the cost per mile picture should stay the same. (Paper 74B)

Papers on which these capsules are based are available in full in multilith form from SAE Special Publications Department. See order blank on page 6.

Attendance Jumps 26%

BETTER than 1900 members and guests attended the SAE National Farm, Construction and Industrial Machinery Meeting and Production Forum held at Milwaukee Auditorium, September 8–11. That represented an increase of 26% when compared with last year's crowd.

No doubt the high quality of the 9 production panels, 7 technical sessions, and the engineering display were responsible for this impressive record.

Not to be outdone, this year's luncheon crowd was 33% greater than last year's. Guest speaker Boyd S. Oberlink, vice-president and director, Allis-Chalmers Mfg. Co., was the crowd-drawer with his talk on "The Road Program—Myth or Fact?"

The Production Forum panels were arranged by a committee under the leadership of General Chairman L. E. Dondero, plant manager, LeRoi Division, Westinghouse Air Brake Co. Forum Sponsor was F. J. Zielsdorf, vice-president and general manager, LeRoi Division, Westinghouse Air Brake Co.

Programs for the technical sessions were planned by a committee headed by General Chairman J. N. Yetter, sales manager, Twin Disc Clutch Co.

Others responsible for arrangements for the meeting included Robert Carlin, reception; A. E. W. Johnson, engineering display; N. P. Mollinger, attendance promotion; and G. E. Smith, publicity.

F. P. Steiner, Meetings vice-chairman for the Tractor and Farm Machinery Activity, and Merlin Hansen, vice-president, Tractor and Farm Machinery Activity discuss a point brought out at one of the technical sessions.

Ideas garnered at the Meeting's Production Forum

MEMBERS of the committee headed by L. E. Dondero who planned the Production Forum held in conjunction with the National Farm, Construction and Industrial Machinery Meeting in Milwaukee, September 8–11 should be credited with a discovery. This is their "discovery."

If you seat three purchasing executives at one end of a table and three engineers at the other end, insert an able chairman between them and invite an audience to listen in, the conversation is almost certain to be interesting. If the members of the panel believe in plain talk, the proceedings will be anything but dull.

Now add a third group. Include a number of vendor engineers in the discussion (including some who wish to express their feelings about an order they lost).

Here you have the makings of a free-for-all, no-holds-barred discussion that the Milwaukee Production Forum was designed to encourage. This wasn't the only session to draw a good audience but there is little doubt this session drew the most conversation after the meeting.

The 1958 Production Forum was developed under the auspices of the national SAE Production Activity Committee. Sponsor of the Forum was F. J. Zielsdorf, vice-president and general manager, LeRoi Division, Westinghouse Air Brake Co.

A study of the subjects included in this year's program offers an opportunity to pinpoint areas of current interest to SAE members. Management planning, job shop operations, plant engineering problems and the relationship of engineering and purchasing were included this year. Other subjects were cost reduction and profit analyzation, new cutting materials, advanced heat-treating techniques, and new welding methods and process control.

Some interesting observations can be made. Automation, a persistent subject of discussion for several years, was not included this year. But subjects like cost reduction, management planning, heat-treating, and small engines continue to draw top interest among SAE members.

Inclusion of an Engineering Display in this year's meeting distorts the comparison, but it is solid testimony to the effective work of Dondero's committee that attendance at this year's meeting hit an all-time high for Milwaukee.

Responsibility of Engineering to Purchasing

The subject, "over-specification," was hotly discussed. Purchasing maintains that its primary responsibility is to hold costs within satisfactory limits although both cost and quality are taken into account in making purchasing decisions.

The feeling of the engineers is that, primarily, they are required to maintain quality. Moreover, it is argued, the testing period, particularly for new products, is often so short there is not time to make adequate tests. Engineers argue this way: they must insist on specifications that fully protect the quality of the product.

Questions from the floor sparked a frank and open discussion of the touchy question of a buyer's obligation to a vendor who has spent considerable time and money on the development of a new product for a particular customer. Purchasing representatives argued that such obligations are not ignored but that they must remain free to make their own decisions. Extensive engineering work should not be undertaken for a prospective customer, it was suggested, unless some understanding has been reached before the work is started.

Engineers feel their contacts with vendor engineers are necessary but that vendor services should be used only to a limited extent.

The consensus was that engineering and purchasing should get together as early as possible in the development of new products.

Purchasing representatives insist they do not buy solely on price; that quality, service, and other factors are constantly being taken into consideration.

Heat-Treating Techniques

Much interest was evidenced in suspended carburizing. Production curtailments at a large auto plant necessitated

at Milwaukee Meeting

SAE President William K. Creson (center) with F. J. Zielsdorf (left) and J. N. Yetter (right). Zielsdorf, vice-president and general manager, LeRoi Division, Westinghouse Air Brake Co., was sponsor of the Production Forum at Milwaukee. Yetter was chairman of the General Committee.

This should be a good panel! That's what Anderson Ashburn (right) was pointing out to J. E. Adams (left) and L. E. Dondero (center). Ashburn is vice-chairman for Meetings, Production Activity. Adams is 1958 vice-president, Production Activity. Dondero was general chairman of the Production Forum.

Monday and Tuesday, September 8 and 9

the development of the method to avoid costly emptying of furnaces.

This interesting conclusion could be drawn from the discussion: the need for dew point controls on continuous furnaces is highly controversial.

The trend to induction heating appears to be increasing. Although induction heating is generally associated with high frequency and high heating temperatures, a new concept here is the use of 60 cycle current for low-temperature stress relieving following heat-treatment.

Induction processing is finding further uses in the field of fillet hardening. Here, the purpose of the operation is to improve mechanical properties and not just raising the hardness.

A recent development in quenching is the use of a new material as an additive to a "water-plastic quench." Less than 1% of the additive is required.

Welding Methods and Process Control

If you're having difficulty achieving satisfactory welding speeds, it was suggested, you use the following check list:

1. Make sure the operator is in the most advantageous position with respect to the controls and the equipment.
2. Study critically the design of the part for welding.
3. Check the soundness of the equipment.
4. Use positioners or manipulators if it is practical to do so.
5. Study the operation carefully to determine whether the work should be taken to the machine or the machine should be brought to the work.

An advantage of CO_2 welding that may not be fully appreciated, it was suggested, is the deep penetration of the arc and the fast weldings speeds that are possible. It was pointed out that CO_2 welding often has an economic advantage over other gases or other welding processes.

CO_2 spot arc welding can often be used effectively to supplement resistance welding. The process can be used to weld material having a maximum thickness of 3/16 in. without providing a hole in the upper piece.

SAE members also learned about a German process, Magna-flash welding or magnetic force welding. Used in Germany for about 5 years, this process produces welds of good appearance. Welding speed is 5–20 fpm. A typical application is a contact that is welded on a member used for circuit breakers. A minimum increase in thickness of the joint results.

Members were also told it is now possible to weld vinyl clad material without marking the vinyl.

Cooling Industrial Air-Cooled Engines

Cut-and-try, used for many years in the design of air-cooled engines, may no longer be necessary. There are now data available in the literature, it was demonstrated, to permit theoretical design of fins for industrial engines. These data cover cooling fundamentals, extended surfaces, and fin spacing.

The process was not described, but it was reported that, using a new material and casting method, it is possible to cast molds and dies to shape, holding tolerances of 0.003 in. The process produces an excellent finish.

Management Planning for Profitable Survival

If you're planning for the future, don't forget these things:

1. Make sure the urgency of your program is recognized.
2. Be sure you have top executive support.
3. Plan for indoctrination of the organization in depth.
4. Encourage enthusiastic participation.
5. Be sure your basic assumptions are sound.
6. Have at least tentative agreement on basic policies and objectives.

What about committee decisions on new products? It was recommended that the line organization should develop new products. However, a committee of specialists, ap-

pointed for the purpose, can do much to expedite the progress of the new product under development. Committee functions usually include gathering of essential data, expediting the program, and serving as "work horse" for the program.

Production Planning for Job Shop Operations

Who is responsible when inventories pile up? After free discussion at the Milwaukee meeting, the finger seemed to be pointing at the Sales Department whose estimates, it was suggested, were largely responsible for the creation of the products. It was conceded that fast action, by manufacturing and sales, working together, could do much to avoid big inventories.

There are booby traps in the machine loading figures sometimes used by production planners. Whereas standard machine ratings are often used in machine loading, it is imperative to know what the operator is getting out of the machine *now*. Is it 80%, 90% or even 110%?

The consensus was that it is good practice to load machines to 80% of rated capacity and then adjust for current production rates, taking into account unpredictable losses in production.

What is a sound basis for a "make-or-buy" decision? Most firms attending the meeting at Milwaukee have "make-or-buy" committees. The minimum job of these committees is to review all marginal items. Following this step, out-of-product costs are studied carefully. Charges generally include direct labor, direct material, and the variable portion of overhead. When cost is determined, quotations are requested from outside firms for the same item for comparison.

New Cutting Materials and Methods

Ceramic tools, it was pointed out, are getting considerable attention. If they are regarded as supplementary tools — and not cure-alls — this attention appears to be well deserved.

Cost of ceramic tools is about twice as much as carbide. Even if the new tools fail to come up to the 1000–2000 sfpm predicted, they can often justify themselves economically.

A new application is interesting: turning rubber wheels. Diamond tools have been used for this application. Boring lead-bronze bearings at 1400 sfpm was also reported. An auto manufacturer has indicated an increase in tool life of 10 times on camshafts.

The nonstrategic nature of the material and the possibility that ceramic tools may soon be used for interrupted cuts were given as reasons for investigating these interesting new cutting materials.

Cost Reduction and Profit Analyzation

If you do things *very* differently than you are now, you may come up with a new product that can be produced at lower cost. This is suggested by the new car, designed by a leading U. S. Industrial Designer, to be exhibited soon at Geneva, Switzerland. The car has one basic frame, but three different bodies can be used with the same frame.

A stopper at the Milwaukee meeting was a prediction by a panel member that the 4-door standard sedan, as we know it today, will disappear. Its replacement will be a station wagon-type body, it was predicted.

A suggestion that got favorable attention was that design engineers should have models of the things they will create *before* they go to work on the drawing board.

Plant Engineering Problems

Plant engineers believe they have key roles in today's economy. Constant review of cost reduction plans and profit analyses help the plant engineer do his work more effectively, it was suggested.

Secretaries' reports of these panels will be available in full in multilith form as SP-324.

Capsule reports of 3 days of technical Construction and Industrial

Tuesday

TURBOCHARGED ENGINES — One of the disadvantages often mentioned against the turbocharged engine for vehicle application is that it is said to have slow response to changes in load. Actually, its response to load change is not much different from that of an equivalent naturally aspirated engine of the same horsepower. It is only when a turbocharged engine is compared with its naturally aspirated version having less power — as is usually done — that the turbocharged engine is likely to show the greater lag. (Paper 75A)

NEW CONSTRUCTION EQUIPMENT — BAT (Ballastable All-Purpose Tractor) and ABC (All-Purpose Ballastable Crawler) are two new members of the Army's growing family of air-transportable construction equipment for use in assault-type operations.

BAT has rear drive by mechanical means, front drive by electrical assist. It is equipped with a 250 hp aircooled engine and, ballastable to 32,000 lb with self-loaded dirt, has twice the capacity of any comparable machine for dozing, scraping, rough-grading, and transporting. Between front and rear operational components it is possible to install numerous construction equipment machines.

The ABC similarly is self-loading and unloading and can be varied as to equipment and work, but has less mobility. Six ABC units can handle 2000 cu yd of dirt in 4 hr, or less than half the time required by six units of commercial equipment. (Paper 75B)

HIGHWAY PROGRAM — After 22 months of activity, the expanded highway program averages about up to schedule among the States. And Federal Aid outlays for 1958, 1959, and 1960 will triple for the years 1954–1956. Some sections will be open for travel by the fall of 1959.

By 1960, when the program reaches its peak, about 442,000 men will be employed on highway construction. Moreover, the program will consume 50,000,000 tons of steel and 1,500,000 bbl of cement.

Looking ahead 20 years, the Interstate Standards call for through traffic lanes 12 ft wide, with 10 ft wide right shoulders carried across all but long bridges. Medians will be at least 16 ft wide in urban areas and 36 ft or more on all rural sections. Underpasses will have full shoulders on the right and 4.5 ft or more left horizontal clearance. Vertical clearance will be at least 14 ft. (Paper 66A)

CLUTCHES — Tests indicate that torque values obtained during clutch engagement are primarily a function of the WR^2 of the engine rather than horsepower. This is explained by the fact that peak torques are encountered in such a short time that the normal governor response is not fast enough to influence them. (Paper 76A)

A mathematical analysis of the engagement of wet-type clutches suggests that the ability to absorb high energy loads can be improved if the clutch torque varies such that the peak rates of heat generation are reduced.

Thus by employing an initially low clutch clamping pressure and gradually increasing to a final high pressure at the end of the engaging cycle, a reduction in the peak rates of heat generation is effected, and the heat load is spread over the entire engaging cycle. (Paper 76B)

sessions at the SAE National Farm, Machinery Meeting, September 9-11

Wednesday

AIR CLEANERS — Low resistance to air flow may make the dry-type air cleaner a strong competitor for the farm tractor business. Although its present capacity or size do not match the oil-bath type, better fuel consumption or horsepower are attractive results when coupled with the dry-type cleaner's ease of maintenance. (Paper 77A)

Studies of filter operation on farm, construction, and industrial machinery show that dry-type filters are reasonable in size and first cost, provide constant high efficiency, and are relatively easy to service and maintain. (Paper 77C)

A "double-dry" filtration system incorporating a Donaclone air cleaner has been developed. Air is drawn into a chamber which is a common entrance to tubes in which the air is rotated by helix vane to create centrifugal force on dust particles. The air spirals down a coned section of tube and, reversing direction at the bottom, ejects dust and dirt. The cleaned air then moves through a filter element to the engine. (Paper 77D)

The Tri Phase Air Cleaner draws dusty air through an tangential inlet causing the air and dust to swirl very much like the well known cyclone cleaner. In the cyclone cleaner the air is made to reverse its direction but here the air is drawn through a center spool or element in a generally straight-through path. The major portion of the dust is centrifuged to the outside and ejected into the dust container. The center filter element does the second and third stages of cleaning by filtering out the medium and fine dust. (Paper 77B)

HYDROSTATIC TRANSMISSIONS — Hydrostatic drive transmissions, which use positive displacement pumps and motors to transmit power, to control speed, or to apply force, have not won the popularity of the hydrokinetic transmission, but they are gaining.

The ease with which control is accomplished, the operational smoothness of high horsepower hydrostatic transmissions, recommend them to the entire mobile field.

Operating pressures of 5000 psi and compactness in design will provide transmissions readily adaptable to vehicles where space limitations are acute. All that's needed to gain the interest of the mobile machinery field in this transmission is a reduction in its cost to make it competitive. (Paper 78A)

Thursday

TRACTORS — Low-speed drawbar tests of rubber-tired and crawler vehicles on macadam, loose ground, and mud showed the geometrically-steered, four-wheel drive and steer vehicles approaching most closely the drawbar characteristics of crawler vehicles. The frame-steered wheel vehicle showed a superiority in its ability to traverse mud.

These were findings of steering and traction tests employing a research vehicle designed for quick change to evaluate 17 drive and steering combinations and thus reduce to a minimum vehicle and test parameters and variables.

Other results of these tests were: High-speed tests on macadam showed the geometrically-steered vehicles to be superior to the skid-steered wheeled vehicles. The variable-ratio type, skid-steer drive comes the closest to approaching the pulling and steering characteristics of the geometrically-steered vehicle. The skid-steered wheeled and crawler vehicles demonstrated their basic superiority in turning in less space than geometrically-steered, four-wheeled and two-wheeled vehicles. (Paper 79A)

Boyd S. Oberlink (center) relates a humorous experience to R. J. Allen (left) and D. G. Thomas (right). Oberlink, vice-president and director, Allis-Chalmers Mfg. Co., and president, Construction Industry Manufacturers Association, was guest speaker at the luncheon. Allen was toastmaster at the luncheon. Thomas is Milwaukee Section chairman.

Many changes are coming in farming equipment and methods. For instance, effort is being applied to design machines which will enable the handling of hay like ear corn by pelleting it in the field. Such a machine would eliminate the hand labor of one of the toughest jobs left on the farm. Furthermore, it would provide a type of product that could be fed on the farm, sold commercially, or be transported to a stationary mill where concentrated pellets could be made. (Paper 79B)

A new tractor has been developed which, mounted on tires, has both four-wheel drive and four-wheel steering. The tractor is said to travel at speeds to 22 mph on any type of road, and can be equipped with many types of tools and implements additional to those used for cultivating and harvesting. Simplicity of design and construction are said to minimize maintenance requirements and eliminate breakage dangers. (Paper T36)

Two models of the new International Harvester tractor line, the F-460 and the F-560, are equipped with a new power steering unit. The entire power unit is incorporated into the front bolster and uses an integral cylinder and rack mounted in an eccentric sleeve which provides rack and pinion backlash adjustment. The manual follow-up is through a ball-nut and screw, endwise motion of which operates the open-center-type steering valve. Smooth, shimmy-proof operation is said to be obtained without losing the desired degree of reversibility and operator feel.

Full control is retained in the event of hydraulic pressure failure and during towing of the machine with the engine dead. All hydraulic connections are O-ring sealed, with pipe thread connections completely eliminated. Bolster shaft bearing and rack and pinion are lubricated by hydraulic oil from the sump side of the steering unit. (Paper 81B)

COMPUTERS — Computers are being used to calculate the maximum safe pay load for cranes and excavators. Using the physical dimensions of the boom's chords, the horizontal and vertical distances between the chords, and taking into consideration the size and pattern of the lacing, it is possible to calculate the allowable pay loads for different boom lengths and various operating conditions. (Paper 80A)

Papers on which these capsules are based are available in full in multilith form from SAE Headquarters. See order blank on page 6.

About SAE Members

Willey

ARTHUR O. WILLEY has become executive vice-president with the Lubrizol Corp., Cleveland, Ohio. He was formerly Lubrizol's vice-president in charge of engineering. Willey is 1958 SAE Councilor and Chairman of the 1958 SAE Meetings Committee.

Henning

Dalenberg

W. W. HENNING, 1957 SAE vice-president representing Tractor and Farm Machinery Activity, has been made manager of engineering for the Farm Equipment Group of International Harvester Co. He was formerly manager of engineering for the company's Farm Tractor Division. He joined International Harvester in 1935.

W. R. DALENBERG, formerly assistant manager of engineering, Farm Tractor Division of International Harvester has been appointed assistant manager of engineering, Farm Equipment Group.

Richardson

Mills

L. A. FLEENER is president of Mercedes-Benz Sales, Inc., a new subsidiary of Studebaker-Packard Corp. Fleener has been general manager of Mercedes-Benz operations since April, 1957.

HAROLD E. CHURCHILL, president of Studebaker-Packard Corp., is chairman of the board.

L. A. RICHARDSON has been named president of Purolator Products (Canada) Ltd. He previously served as vice-president and general manager. During World War II, he served as a major with the Royal Canadian Electrical and Mechanical Engineers. After his release in 1944, he formed the Canadian company of Purolator in Toronto.

Wright

Manhart

BEN D. MILLS is now vice-president of Ford Motor Co. and general manager of Mercury-Edsel-Lincoln Division. Formerly, he was vice-president and former assistant general manager of the Division. Mills is succeeding JAMES J. NANCE who resigned.

O. A. WRIGHT has been elected vice-president of Actuation Research Corp. of Glendale, Calif. He joined Actuation Research Corp. early in 1957 as engineering manager. He is an active member of the SAE A-16, Aircraft & Missile Fuel, Oil & Oxidizer Systems and A-6C, Hydraulic Pumps, Motors & Air Compressors Committees.

CHARLES D. MANHART, former director of military and government sales at Bendix Aviation Corp., has been elected vice-president, Government relations, for Raytheon Mfg. Co. He will have full responsibility for strengthening, expanding, and coordinating all phases of Raytheon's relationships with the Armed Forces and other Government agencies in order to meet their needs most effectively.

ARMAND W. WOTHE has become vice-president in charge of sales and engineering, Hendrickson Tandem Corp., Butler, Ind. He is also sales engineer with Hendrickson Mfg. Co., Lyons, Ill.

E. V. ALBERT, current vice-chairman of San Diego Section, has been appointed manager of the San Diego territory of General Electric Co.'s Aviation and Defense Industries sales department. Prior to this, Albert had been supervisor of transport engine planning and manager of product planning in the General Electric jet engine department, Cincinnati, and aircraft propulsion specialist in San Diego.

ALLAN CHILTON, former chief engineer for the aviation gas turbine division of Westinghouse Electric Corp., has been named manager of Westinghouse's newly formed Weapons Systems Planning Group. The group will study overall requirements of future military activities.

Wothe

Albert

Chilton

Bechman

Bennett

King

W. O. BECHMAN has been made assistant to the general manager of International Harvester Co., Construction Equipment Division.

MERRILL R. BENNETT has become manager of engineering of the Division to succeed Bechman. Formerly, he was assistant manager of engineering. Bennett was 1957 SAE vice-president representing Diesel Engine Activity.

JOHN H. KING has been appointed manager of the motor truck department of the Automobile Manufacturers Association. King has been a member of the Association's staff for 14 years, serving as Washington observer-reporter of transportation trends affecting use of motor trucks.

JAMES C. ZEDER, Chrysler's vice-president of engineering and special advisor to the president, is continuing to expand his contributions to development of engineering education in American universities. Most recently, SAE's 1950 president has accepted an assignment to be vice-president and chairman of the program committee for Michigan State University Oakland—a new autonomous branch of Michigan State University.

To begin planning engineering curricula for the new institution (which will open in the fall of 1959 with 550 freshmen), Zeder chairmanned an exploratory meeting attended by the country's leading engineering educators. In the group were: Dr. John A. Hannah, president of Michigan State University; Dr. Eric A. Walker, president of Pennsylvania State University; and Dr. C. Richard Soderberg, dean of engineering, Massachusetts Institute of Technology.

Also present were Dr. Lee A. DuBridge, president of California Institute of Technology; Dr. NEWMAN HALL, professor and chairman of mechanical engineering, Yale University; Dr. Frederick E. Terman, dean of engineering, Stanford University; and Dr. John D. Ryder, dean of engineering, Michigan State University.

Similar symposiums are to be held in the near future with outstanding educators to cover the administration, teacher education, and liberal arts fields.

GEORGE O. GALE has become manager-engineering, DeSoto Division, Chrysler Corp. He was previously assistant chief engineer with the same firm. He will now be responsible for coordinating styling, engineering, manufacturing, and quality activities.

KEITH W. TANTLINGER has been appointed vice-president, engineering, for Fruehauf Trailer Co., Detroit. He was previously vice-president, engineering, with the Waterman Steamship Corp., Mobile, Ala.

Gordon

Curtice

JOHN F. GORDON has been named president of General Motors Corp., succeeding **HARLOW H. CURTICE,** who has retired but continues as a member of GM's Board of Directors.

Gordon will also be chairman of the corporation's newly formed executive committee, which will be generally responsible for management of the corporation's business affairs. For the last 7½ years, he has been a corporation vice-president and group executive in charge of body and assembly operations.

Gordon has been an engineer throughout his career; joined SAE in 1943, the year he became chief engineer of Cadillac. He started with a master's degree in mechanical engineering from University of Michigan in 1923, following graduation from U. S. Naval Academy in 1922.

He has been with General Motors for 35 years, beginning as a laboratory technician with Cadillac in September, 1923. He took several steps upward in Cadillac's engineering department before being transferred to Allison during the war in connection with product study work on special engines. But 1943 brought him back to Cadillac, this time as chief engineer. Three years later, he became Cadillac's general manager. Then, following a brief six months as vice-president in charge of GM's engineering staff, he was elected to GM's board of directors and took over his assignment as a group executive in charge of body and assembly divisions.

CURTICE is also a member of SAE, having joined in 1930.

Frederic G. Donner has been named chairman of the board and chief executive officer of General Motors, succeeding Albert Bradley, who has retired.

DAVID H. EDWARDS has become product development engineer (test), Transmission and Axle Division, Ford Motor Co., Livonia, Mich. He was previously project engineer, with U. S. Army Ordnance at the Aberdeen Proving Grounds, Md.

MICHAEL W. WEST has been made district manager for Mack Trucks, Inc., Richmond, Va. Formerly he was branch manager, Fruehauf Trailer Co., Atlanta, Ga.

J. B. ROSENQUEST has become vice-president and general manager, Leonard Mack Co., Albuquerque, N. M. Prior to this he was division manager, Mack Trucks, Inc., Plainfield, N. J.

D. W. PETERSON has been made quality engineer, Pioneer Saws Division, Outboard Marine Corp., Waukegan, Ill. He was formerly project engineer, Clinton Engine Co., Maquoketa, Iowa.

JONATHAN E. BORETZ, former senior project engineer at the Stratos Division, Fairchild Engine & Airplane Corp., is now associated with The Martin Co., Denver Division. He is principal engineer in charge of the Development Unit, Propulsion Section, Aeronautics Department.

MARK E. RASPER has been named sales manager of automotive assemblies for the Moraine Products Division of General Motors Corp. Formerly with GM's Delco Products Division, Rasper was sales manager of fractional horsepower motors and manager of the Detroit office for that division.

FRANCIS J. MARKEY has become sales manager of brake fluids for the Moraine Products Division of General Motors. Markey is chairman of the SAE Hydraulic Brake Fluids Subcommittee.

continued

Curtiss-Wright President
Roy T. Hurley Says . . .

C-W and N.Y.U. Form Solar Energy Programs

THE Curtiss-Wright Corp. and New York University have initiated joint and separate programs for the research, development, and practical application of solar energy. The programs will be carried out at the Princeton Division of Curtiss-Wright and will be under the direction of Dr. Maria Telkes, internationally-known solar scientist.

Curtiss-Wright, Hurley said, is entering the field of solar energy with immediate emphasis on the development and production of commercially salable solar products, based upon existing patents, knowledge, and needs.

It is anticipated that New York University's participation in the joint program will generate many new and basic discoveries in the field of solar energy.

A complete Sun Court and Solar Laboratory is now under construction at Princeton. The Sun Court includes a solar-heated house and a solar-heated swimming pool, solar furnaces, solar batteries, solar stills, solar driers, solar cooking equipment, solar radios, and solar food-processing equipment.

"Our basic business is converting energy into usable power," Hurley said. "The energy from the sun's rays offers the greatest potential source of power for the improvement of standards of living known to man. The amount of sunshine falling on one acre in a year in the temperate New York City area is the equivalent of the energy from 850 tons of coal which has an approximate value of $8500. In desert and tropical areas it is even higher. An acre-year of sunshine in Reno, Nev., for example, equals 1300 tons of coal or $13,000.

"The standards of living of millions of people in parts of the world where fresh water and fuel are in short supply can be improved by harnessing the power of this tremendous source of energy."

FRANCIS W. DAVIS is the donor of a new exhibit — Power Steering and Hydraulics — at the Boston Museum of Science. "Working models, diagrams, large photographs, and two steering wheels tell the story of the development of power steering since it was first conceived by Mr. Davis in his Waltham shop in the early 1920's."

JOSEPH T. OSTERMAN has been named as Chicago district representative of Electric Auto-Lite Co.'s Electrical Products Group. He was formerly assistant manager of the Chicago regional office of the American Bosch Division of American Bosch Arma Corp.

D. W. MANSELL has been made assistant sales manager, Cummins Engine Co., Ltd., Lanarkshire, Scotland. Prior to this he was export director-sales for the National Gas & Oil Engine Co., Ltd., Ashtan-under-Lyne, England.

PAUL W. LEAK has been appointed chief engineer, sales engineering, with the Norma-Hoffman Bearings Corp. He has been with the corporation since 1947, and was formerly assistant chief engineer.

DELMAR G. ROOS has moved the Engineering Offices of Delmar G. Roos and Associates to 6 Merestone Terrace, Bronxville, N.Y. Roos was SAE's President in 1934.

E. T. WALTON, former metallurgical engineer, has been named manager of Customer Technical Services of Crucible Steel Co. of America. In his new capacity, he directs the provision of technical services in all customer areas, as well as directing the Division's Specification Service and Technical Data Section. He has been associated with Crucible since 1923 when he joined the Midland Works staff as contact metallurgist.

LA VERNE MORGAN has been named shop superintendent for Cummins Service and Sales, Southern California Distributor of Cummins diesel engines. He will have supervision over the company's shops at Los Angeles, Bakersfield, and Montebello. He formerly served as manager of the shops at the Oakland plant of the Edward R. Bacon Co.

R. L. VROMAN has assumed the responsibilities of design supervisor in Dodge truck engineering — Heavy Duty Truck Section, Chrysler Corp., Detroit. He was formerly a design leader in this same group.

WENDELL S. SMITH has been appointed manager of Casco Products Corp. Detroit office. He has been a manufacturer's agent for Casco since 1945.

GEN. JAMES H. DOOLITTLE has become chairman of the Board of Directors of the Space Technology Laboratories, previously a division of Ramo-Wooldridge Corp. Doolittle will continue as a member of the Board of Directors of Shell Oil Co., but he will retire as vice-president of that organization at the end of the year.

ALBERT F. WELCH has been appointed to head the new electronics-instrumentation department of the Research Laboratories Division of General Motors Corp. Prior to this, he has been an assistant department head at the Laboratories.

JOHN R. MORROW, previously assistant sales manager in charge of the Needle Roller Division, Kaydon Engineering Corp., has been assigned to Casco's Detroit office.

FRANK H. ERDMAN has been named president of Kett Technical Center, Inc., research and development center of U.S. Industries, Inc. Immediately prior to joining U. S. Industries, he was engaged in business for himself.

ROBERT W. BROBERG is now associated with Mechanics Universal Joint Division of Borg-Warner Corp., Rockford, Ill., on a special assignment to the president. He was previously staff engineer, Aero Division, Vickers, Inc., Detroit.

MICHAEL F. DeMARCO has been made field service representative with Chance Vought Aircraft, Inc., Virginia Beach, Va. He was formerly field service representative, United Aircraft Service Corp., Hartford, Conn.

STANLEY H. UPDIKE is a project engineer, Thompson Products Co., Mentor, Ohio. He previously held a similar position with Schwitzer Corp., Indianapolis, Ind.

DR. ROBERT J. NEBESAR has been appointed general manufacturing manager, Zenith Plastics Co., Gardena, Calif. He was previously vice-president, Plastics Division, Universal Molded Products Co.

D. N. McNALLY has been made technical engineer, Small Aircraft Engine Department, General Electric Co., Lynn, Mass. He was formerly design and analysis engineer, Sikorsky Aircraft Division of United Aircraft Corp., Bridgeport, Conn.

FRED E. CARLSEN has been named assistant to the president of John J. Casale, Inc., New York City. He was previously operations assistant with Seatrain Lines, Inc.

MARSHALL E. BECKER has become design engineer, with the Sancor Corp., El Segundo, Calif. Prior to this he was a design engineer, Northrop Aircraft Corp., Hawthorne, Calif.

GEORGE R. THALMAN is now chief engineer, Poroloy Section, Bendix Filter Division of Bendix Aviation Corp., Royal Oak, Mich. He was previously chief engineer, Poroloy Equipment, Inc., Van Nuys, Calif.

J. E. CARDILLO has been appointed general manager of manufacturing and engineering — staff, Federal-Mogul-Bower Bearings, Inc., Detroit. He was formerly assistant general manager with the same firm.

F. D. APPLEGATE has been made project engineer for all ground support equipment for the Convair F-102 and F-106, Convair Division, General Dynamics Corp. He previously held the position of project engineer for the F-102 and group engineer for propulsion design. He was 1957–1958 chairman of SAE San Diego Section and has been a representative for San Diego Section on the SAE National Sections Committee.

JAMES F. BOARD has been appointed product engineer, Carter Carburetor Co., Division of American Car and Foundries Inc., St. Louis, Mo. Previously, he was design engineer, Bendix Products Division, Bendix Aviation Corp., South Bend, Ind.

continued on page 110

FREDERICK EWAN MOSKOVICS, for 50 years a member of SAE, received on August 11 the Exceptional Civilian Service Award — the highest honor the Air Force can present to its civilian employees.

Moskovics was given this award for his work as Special Consultant to the Commander, Air Materiel Command, from February, 1952, to June, 1954. When he completed his award-winning assignment, he was 75 years of age. The citation read in part:

> "Through his special studies of the B-52 and J-57 programs, he recommended production methods and materials which enabled manufacture in mass production at reasonable costs and estimated costs which were of vital importance in budgeting Air Force funds."

The presentation was made by Gen. E. W. Rawlings, Commander, Air Materiel Command, at a luncheon at the Engineers Club in New York.

Moskovics, still an industrial consultant with A. O. Smith Corp., expressed his deep appreciation for the honor, then added:

> "It is my hope that this may encourage others of my age, whom circumstances permit, to seek and accept opportunities for continued activity and service."

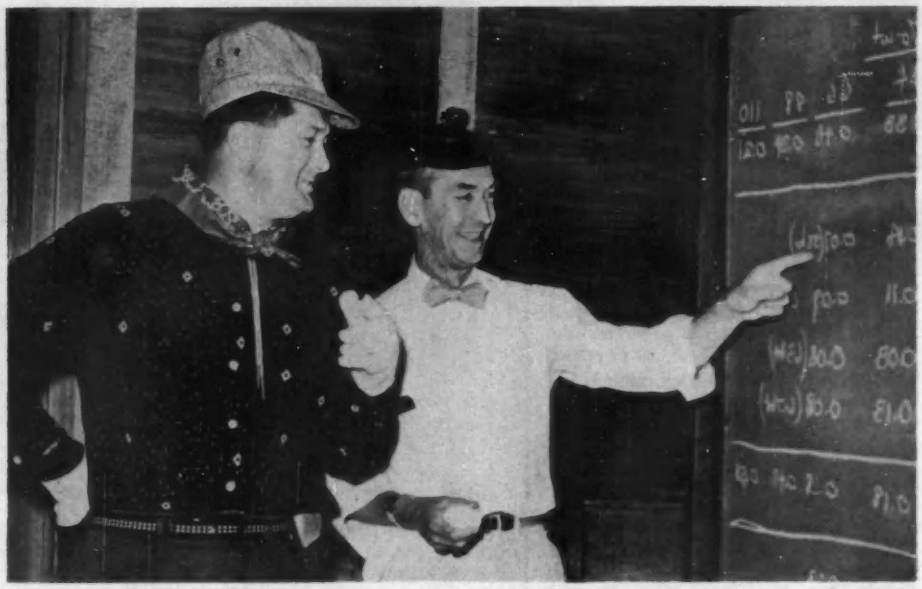
Moskovics, who will be presented later this year with a certificate honoring his 50 years of SAE membership, was elected to SAE membership on Oct. 24, 1908 . . . two days after his application had been received. Sponsoring him for membership were Henry Ford, A. L. McMurty, C. E. Duryea, Howard Coffin, and C. R. Grueter.

In the years since then, Moskovics has held many posts of high executive importance in the automotive industry including those of vice-president and manager of Remy Electrical Co.; vice-president and commercial manager of Nordyke & Marmon Mfg. Co.; and president of Stutz Motor Car Co. But through all the years since 1908, he has continued active and interested in the meetings and affairs of the Society. He has missed only one SAE Annual Meeting in the last 50 years — and was chairman of the Reorganization Committee and the Constitution Committee which brought about the reorganization of the Society's structure in 1929, following its first 25 years of operation.

His association with A. O. Smith and his outstanding services to the Air Force came some years following his "retirement" from 1932 to 1936 to handle personal affairs. Following four years as chairman of the executive committee of the Dictograph Corp., came World War II and several years of service to the then Army Air Corps.

He became associated with A. O. Smith in 1944, where he has been an industrial consultant ever since, with the exception of his two-year leave of absence for the work with the Air Force which has brought him the Exceptional Civilian Service Award.

CEP NEWS



As fellow Filter Test Methods Subcommittee members often saw him, Chairman R. J. Pocock 'engineers' his way through a tough technical problem with Sherod Earle.

Filter Test Gains Technical Board Approval

THE first crankcase oil filter performance test to be developed cooperatively *by* industry *for* industry use has been approved by the Technical Board as a new SAE Recommended Practice.

The test is reprinted in full on the following pages because of wide-spread interest shown both here and aboard in the report's progress over the past ten years.

Test requirements reflect the concerted effort of Filter Test Methods Subcommittee members to eliminate possible sources of variation in test results.

Major Problem

A major problem was the selection of standard contaminant materials, according to Subcommittee Secretary F. C. Koch. A natural and a synthetic contaminant were finally chosen. Initially, processing and handling of the *natural* contaminant gave great variation in test results.

To stabilize test results using the natural contaminant, a centrifugal-type pump was selected instead of a gear-type pump since the latter 'ground' the contaminant in a way which progressively reduced particle size.

During the first stages of investigation, mixing was done by recirculating one gallon of the contaminant through a gear pump. As small amounts were withdrawn for testing and the turnover rate of the contaminant in the mixer increased, filtering became more difficult, if not impossible. This problem was completely solved by use of a larger reservoir and a centrifugal pump.

The new recommended practice will be available from SAE Headquarters in separate form as TR 160 by November 1.

Filter Test Methods Subcommittee

R. J. Pocock, Chairman
Ford Motor Co.

F. C. Koch, Secretary
Detroit Arsenal

E. R. Adams
Commerical Filters Corp.

F. P. Babcock
PurOlator Products, Inc.

S. L. Earle
U. S. Naval Engrg. Exper. Sta.

R. D. Hiserote
Caterpillar Tractor Co.

W. G. Nostrand
Winslow Engrg. Co.

G. E. Anderson
Assn. of American Railroads

R. L. Bowers
AC Spark Plug Div., GMC

Daniel Fairchild
Fram Corp.

K. E. Humbert, Jr.
Wix Corp.

T. C. Sauer
PurOlator Products, Inc.

S. A. Casale
Fram Corp.

R. K. Hathaway
Walker Mfg. Co.

Walter Kasten
Bendix Aviation Corp.

Introducing SAE's New

Lube Oil Filter Performance Test

SAE Recommended Practice

Report of Engine Committee approved September 1958

Introduction

Recommended materials, apparatus, methods and procedures have been compiled for laboratory testing and evaluation of automotive-type lube oil filters. Both partial- and full-flow types are covered to provide a somewhat universal standard for determining filter performance. No limitations have been placed on performance requirements and/or tolerances. Rather, it is the intention that a basic means of comparison only be provided. A lube oil filter whose performance is known in a definite application can then serve as a reference in these laboratory tests. Since end product performance may differ considerably for the many types and sizes of filters, test requirements are the responsibility of the user and vendor. The use of these test procedures is entirely voluntary.

Laboratory testing experience acquired over a number of years has revealed potential dangers, not generally recognized, which could contribute to false impressions and knowledge concerning filter capabilities. Attempts have been made herein to at least minimize the causes of discrepancies by designating precautionary measures to be observed in the testing process. Even in strict compliance with details given herein, some variations in results are to be expected. However, the degree of reproducibility and repeatability of the test methods is considered sufficiently reliable to depict the comparative life and efficiency of filters popularly used with today's automotive engines. Even with laboratory test data so obtained, performance of a specific type of filter, when applied to a particular engine, cannot necessarily be predicted unless singular operational characteristics of the engine are known and can be related to the laboratory test. In the light of this, the limitations of the test standard should be realized.

No laboratory bench test method presently exists which precisely duplicates performance of an engine installation. Therefore, this test standard should be considered only a "yardstick" of measurement. Although engine operating conditions are not necessarily reflected because of differences in driving habits, engine designs, fuel and oil improvements, and other changes which are progresively taking place, a good means of filter comparison is provided under these particular "static" test conditions.

This test method has been designed primarily to determine filtering ability. Other functional features of filters are of equal importance and require separate tests to obtain a more complete filter evaluation. Included in this category are restriction to flow as measured by flow-rate versus pressure-drop, media migration, oil-additive removal and/or compatibility, shock and vibration resistance, and moisture and pressure resistance. Further details concerning these tests should be sought from Government and industry specifications.

In general, the test procedure is concerned with four main elements, namely:

- Selection and processing of standardized contaminants.
- Contaminant storage, handling and addition.

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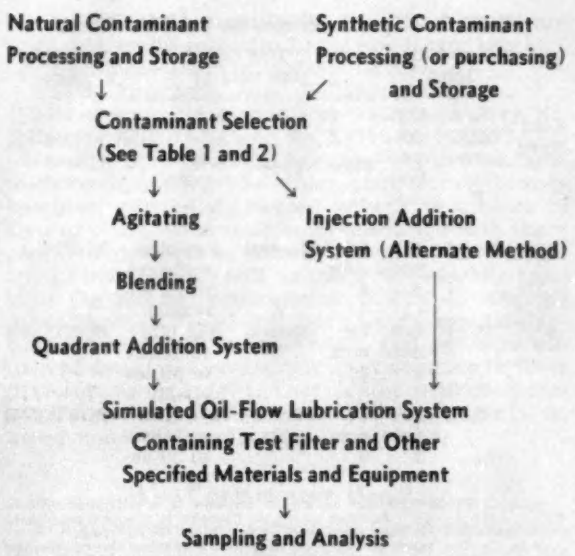

Natural Contaminant Processing and Storage
Synthetic Contaminant Processing (or purchasing) and Storage
Contaminant Selection (See Table 1 and 2)
Agitating
Blending
Quadrant Addition System
Injection Addition System (Alternate Method)
Simulated Oil-Flow Lubrication System Containing Test Filter and Other Specified Materials and Equipment
Sampling and Analysis

Fig. 1 depicts the steps involved in the complete testing procedure.

- A simulated oil-flow lubrication (test) system.
- A method for analysis.

Oil under controlled conditions of flow rate, temperature, and pressure, is circulated through the simulated lubrication system containing the test filter. A measured quantity of the selected and processed contaminant material is introduced from an addition system in small increments at a substantially uniform rate. It is dispersed throughout the recirculating oil stream. (The addition system may contain a quadrant or injector.) As it becomes part of the influent to the filter, the filter is given the opportunity to remove the solid particles of the sludge from the flow system. Progressive filtration takes place during test, depending upon the capabilities of the filter. Quantities of test materials and/or reagents may be altered, within reason, to suit individual filter needs. Thus, an adjusted level or gradient of performance with no resulting detrimental effects to the applicability of the test method is provided.

At prescribed intervals, samples of oil are removed from the system and analysed for solids (n-pentane insolubles) content. The samples must be carefully selected and analysed. Subtracting the insolubles value obtained in the analysis from the known value added to the system over the same period of time yields the amount removed by filtration. From these figures, filtering efficiency can be calculated. Fig. 1 depicts the steps involved in the complete testing procedure.

Table 1 — Test Conditions for Partial Flow Filters

	Oil at Filter Inlet		Test Oil (See note 1)		Contaminant
Test Type	Temperature, F	Pressure, psi	Type	Quantity	Designation
1	180 ± 5	40 ± 1	Mineral	5 qt plus sufficient to fill assembly	SOFTC-1
2	180 ± 5	40 ± 1	Mineral		SOFTC-2A
3	180 ± 5	40 ± 1	Additive		SOFTC-2B

Note 1: Straight mineral oil should conform to specification MIL-L-15016, symbol 3065. Additive oil should conform to specfication MIL-L-2104, grade SAE 30. Use Material 4.3.1.4 of MIL-F-20707, page 4.

Table 2 — Test Conditions for Full Flow Filters

	Oil at Filter Inlet		Test Oil (See note 1)			Contaminant
Test Type	Temperature, F	Differential Pressure, psi	Flow	Type	Quantity	Designation
4	180 ± 5	See note 2	See note 3	Mineral	5 qt plus sufficient to fill assembly	SOFTC-1
5	180 ± 5	See note 2	See note 3	Mineral	5 qt plus sufficient to fill assembly	SOFTC-2A
6	180 ± 5	See note 2	See note 3	Additive	5 qt plus sufficient to fill assembly	SOFTC-2B

Note 1: Straight mineral oil should conform to specification MIL-L-15016, symbol 3065. Additive oil should conform to specfication MIL-L-2104, grade SAE 30. Use Material 4.3.1.4 of MIL-F-20707, page 4.

Note 2: The maximum differential pressure reached during the test should be that pressure at which the by-pass pressure relief valve (for the particular filter assembly under test) is set.

Note 3: The flow rate maintained should be the rated flow of the filter assembly.

I — Standardized Contaminants, Selection and Processing

A. Natural Contaminant is designated "standardized oil filter test contaminant No. 1" (SOFTC-1) for identification purposes.

1. Natural contaminant SOFTC-1 is derived from engine crankcase drainings. Used oil is collected from automotive service stations and any other available source over a wide area and during all seasons of the year. It is combined and stored in large tanks so that partial settling is allowed to take place in a limited period of time. The top portion of this oil is withdrawn, leaving the larger and heavier bottom (including water) settlings behind, so that solid-particle content larger than 5 microns does not exceed 5% by count of the total solids. The used oil is processed further to reduce water content not removed by settling, and screened to remove undesirable debris. It is further concentrated by settling and then is pumped through a filter press. The resulting concentrate is removed from the press and blended with new straight mineral oil to obtain a solids content of 25% by weight.

SOFTC-1 is specified as:

Petroleum Ether Insolubles, %	25 ± 1
Petroleum Ether Solubles, %	75 ± 1
Water, % max	1.0

2. SOFTC-1 by the nature of its origin is not a fixed product, but one which changes in step with the changes in lubricating oil, their additives, engine design and operation, and driving habits. Therefore, a fixed specification controlling its chemical composition is neither practical nor desirable. A product such as this can differ widely both in chemical and physical nature, depending upon the processor, and still be perfectly satisfactory for test purposes. Special precaution should be taken to see that extraneous matter in the nature of cellulose and/or other fibers are kept out of the final product. A typical chemical analysis is quoted below to illustrate general composition of a previously satisfactory contaminant.

Chemical Analysis by Weight	
Water	0.3 %
Petroleum Ether Insolubles	24.60
Petroleum Ether Solubles	75.10
	100.00%

Analysis of Petroleum Ether Insolubles (24.60%)	
Chloroform Solubles	8.8%
Chloroform Insolubles	91.2
	100.0%

Analysis of Chloroform Insolubles (91.2%)

Carbonaceous Matter	52.6%
Ash	47.4
	100.0%

Analysis of Ash (47.4%)

Iron Oxide	17.28%
Alumina	Trace
Copper	0.56
Lead Oxide	33.33
Silica	18.40
Calcium Oxide	3.91
Manganese	0.02
Phosphorus	1.48
Barium	Nil
Sodium	Trace
Potassium	Nil
Zinc	Nil
Magnesium Oxide	0.12

The balance is mostly sulfates

3. Particle size analysis by count follows:

Particle Size	% of Total
0–2 Microns	60.4
2–5 Microns	36.1
5 Microns and Over	3.5
	100.0

4. In preparing SOFTC-1, the processor should realize and observe the importance of maintaining good quality control. He should have storage tanks and equipment large enough to meet demands without excessively depleting reserves or interfering with his prescribed refining procedures. Continuous agitation (or circulation by means of nongear-type pump) of the final product should be maintained when storing in a single large quantity. Packaging in 1-gal containers immediately after processing precludes this continuous agitation and provides representative sampling and supply to the consumer, although at higher cost. By processing batches representing staggered collections over a period of a year or more, a gradual rather than an abrupt change in finished product is obtained, and the consumer is better able to correlate test results from year to year. At the same time, the contaminant continues to reflect, at least to some degree, current engine operation conditions. Since there is presently no approved market source of SOFTC-1, its use is confined to those individuals and organizations who are able to do their own collecting and processing.

B. Synthetic Contaminants are designated SOFTC-2A and -2B.

1. As the names imply, they are synthetic mixtures of ferric oxide, carbon black, and PV resin powder of graded sizes blended in mineral oil, in proportions by weight of 22% solids, 78% oil. SOFTC-2A contains straight mineral oil while SOFTC-2B contains heavy-duty additive oil. The specified composition of SOFTC-2A and SOFTC-2B solids is:

a. Sixteen parts by weight of carbon black, average particle size of 85 millimicrons.

b. Two parts by weight of ferric oxide, 95% by count of the particles in the range from 0 to 5 microns.

c. Four parts by weight of PV* resin, the particle sizes of this material as follows:

100% to pass through a 30 mesh screen
90% to pass through an 80 mesh screen
60% to pass through a 200 mesh screen

2. SOFTC-2A and SOFTC-2B contaminants are available, ready-mixed in 10 gal and larger lots at:

Baltimore Paint and Color Works
2325 Annapolis Ave., Baltimore, Md.

(Reference should be made to their laboratory No. X7686 for SOFTC-2A and No. X7716 for SOFTC-2B.)

3. SOFTC-2A and -2B, because they are synthetically compounded and their composition closely specified, can be duplicated at will regardless of time or place. Therefore, tests conducted with these contaminants over an extended period of time (other things being equal) will be more reproducible than with the natural contaminant SOFTC-1. On the other hand, SOFTC-1 will more nearly simulate actual automotive filter operation, and perhaps will help to detect changes which must be made in filter performance in order to keep in step with changing conditions. Partiality for the latter material is based upon this comparison.

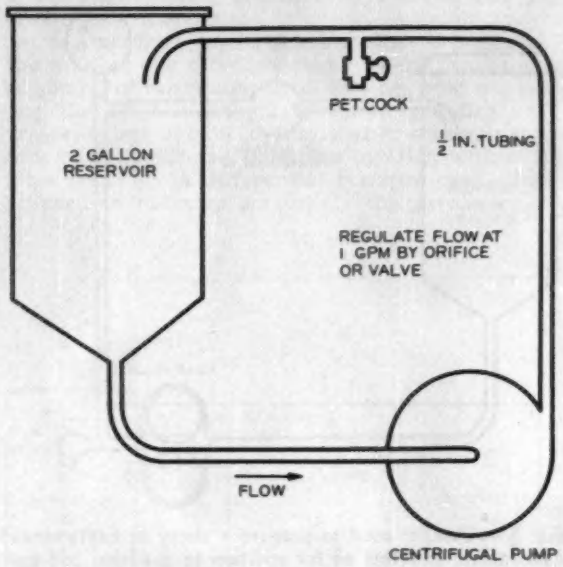


Fig. 2 — Unit for agitating the contaminant concentrate.

II — Contaminant Handling

A. The Standard Contaminant Concentrate when purchased in 1-gal cans should be dated and the container inverted and stored so that opening access is on the bottom. Prior to contaminant usage, warm contents of can to approximately 180 F, shake thoroughly, and transfer contents from can being sure

* PV resin is a natural resin product identified as item No. 514 of the National Biochemical Co., 3106 W. Lake St., Chicago 12, Ill.

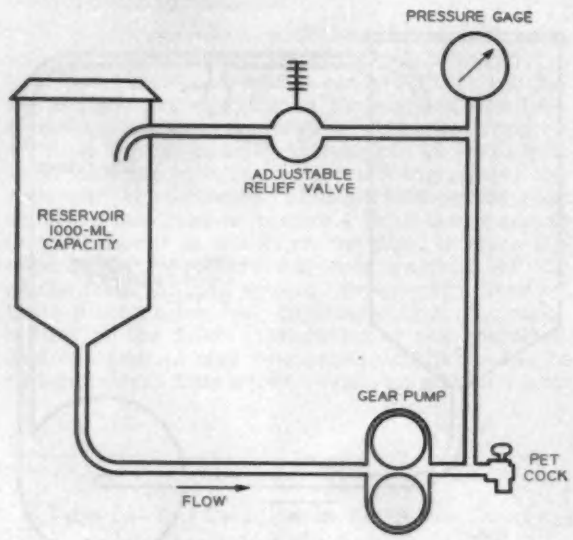


Fig. 3 — Blender used to prepare a slurry of contaminant concentrate and test oil for addition to quadrant add system.

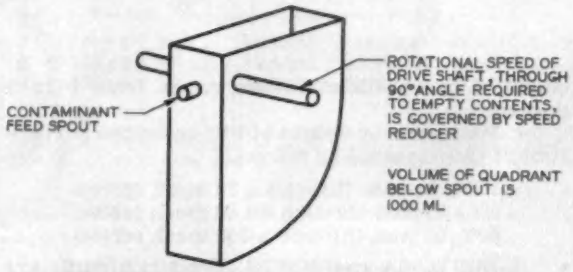


Fig. 4 — A quadrant add unit with a volume of 1000-ml.

all contaminant is removed.

B. Place 2 gal of Standard Contaminant in the agitator (Fig. 2) and recirculate through a centrifugal impeller type pump 3450 rpm, 18 gpm at 2.3 ft head. Regulate flow of contaminant through the pump at 1 gpm. Depending upon ambient conditions, oil temperature normally falls within the range of 135 to 160 F during circulation in the agitator. Continuous operation of the agitator may be maintained throughout the filter test, but the contaminant must be agitated by circulation through the centrifugal-type pump for at least 1 hr immediately prior to each addition to the blender or injector. Re-establish original contaminant level when approximately 1 gal of contaminant has been removed from the agitator. Re-establishment of the original level is necessary to prevent "working" of the contaminant by a high turnover rate in the pumping cycle. Remove a sample of the contaminant from the agitator original charge (after 1 hr of operation) and after each addition of contaminant to the agitator (after 1 hr of operation). The samples thus removed are analyzed to determine the percentage of solids content using the petroleum ether and n-pentane insolubles analysis procedure. Homogeneity of contaminant being added to the blender or injector must be assured. The importance of having a truly representative material for addition to the testing system cannot be overemphasized.

C. When the Injector Device is employed to add contaminant to the testing system, the contaminant is transferred directly from the agitator to the injector. Stroke length and speed of the injector is regulated in accordance with the required add rate. Description of a suitable injector is found in Paragraph F. When a quadrant device is employed to add contaminant to the testing system, blending of contaminant with oil precedes transfer to the quadrant.

D. Contaminant Blending refers to the blending of test oil and standard contaminant for use as a slurry addition to the filter test system by means of a quadrant add device. Place a portion of test oil taken from oil sump into the blender (Fig. 3). From the agitator, weigh a quantity of contaminant (weight depends on solids concentrate of contaminant found in Paragraph B) necessary for the selected-solids add rate and add this to the oil in the blender. Selection of the solids add rate should be based upon the size and capacity of the test filter and upon a convenient and reasonable test duration. Recirculate blender slurry for 1 hr through a gear-type pump (helical-gear motor-driven gear pump — 1725 rpm, delivering 4.6 gpm at 0 psi head) prior to transfer to the quadrant add system. Circulate slurry at 30 psi by adding a variable restriction to the blender pump outlet line.

E. Transfer Complete Blender Slurry Contents to quadrant (Fig. 4) add device. The quadrant add system should be designed and constructed to introduce contaminant into the testing system in small (dropwise) increments at a substantially uniform rate. If the 1-hr blending period is completed at the beginning of a shutdown period (or at the end of a working day), an additional ½-hr mixing period should precede the transfer of the slurry to the quadrant add system prior to the resumption of test. Quadrant add periods of 4 or 5 hr are recommended for test purposes, but should never exceed 8 hr or employ a slurry concentration exceeding 2% solids. Experience has shown that a liter of slurry containing 10 g of contaminant solids added to the testing system over a period of 5 hr constitutes a satisfactory add rate for ordinary automotive size lube oil filters.

F. Terminology and Nomenclature

1. Agitator —— Unit for agitating the contaminant concentrate. (See Fig. 2.)

2. Blender —— Unit for blending a slurry of contaminant concentrate and test oil in preparation for addition to quadrant add system. (See Fig. 3.)

3. Slurry — The mixture of contaminant concentrate and test oil to be used for the quadrant add unit.

4. Quadrant Add Unit —— Slurry addition unit having a 1000-ml quadrant driven by the following through suitable reduction (See Paragraph E).

Reducer, speed ratio 900–1
Torque Output, 100 lb.–in.
See Fig. 4 for quadrant details.

5. Centrifugal-Type Pump ——
Centrifugal impeller-type pump
18 gpm, 2.3 ft head
1/10 hp motor, 3450 rpm

6. Gear-Type Pump ——
Gear-type pump
1725 rpm
4.6 gpm at 0 lb pressure
Pipe connections, $\frac{3}{8}$ in.

7. Motors —— $\frac{1}{2}$ hp, 1725 rpm, 115/230 v

8. Contaminant —— Standard contaminants purchased as follows:
SOFTC-2A and 2B.
Baltimore Paint and Color Co.
Baltimore, Md.

9. Injector —— Alternate contaminant add device.
B. I. F. Industries
Providence, R. I.
Model HP-VS, Type 07

III — Test Apparatus and Procedure

A. Test Equipment (assembled to simulate a lubrication system) and instrumentation shall consist of:

1. A sump of ample capacity provided with a conical or pyramidal bottom with the included angle at the apex not more than 120 deg wherein the oil flowing to the filter is obtained from the lowest point in the sump. The conical or pyramidal bottom must extend from the bottom-most point out to the vertical walls, if any walls are vertical. The sump must be provided with a means for heating the oil contained therein. See Fig. 5.

2. A pump on the outlet side of the sump as near to the sump outlet as may be practical. This pump should be of a type which most nearly simulates the engine lubrication system and of a capacity and rating suitable for maintaining adequate flow rate and pressure in the system. For partial flow, the pump should be controlled to deliver at least 5 times, but not more than 10 times initial rated flow of the filter being tested. For full flow, the pump should be controlled to deliver not less than 120% nor more than 150% of the rated flow of the filter being tested.

3. A sampling valve located immediately downstream from the pump and installed so as to minimize contaminant entrapment in or near the valve.

4. A bypass valve and piping to return oil directly to the sump and to help adjust flow through the section of the system in which the filter is located. All piping, tubing and fittings should have maximum bore smoothness to minimize stagnant conditions, "pockets", and deposition of dirt during test, and to facilitate cleaning between tests.

5. A shut-off valve located in the section of the system in which the filter is located to prevent oil circulation through the filter during warm-up periods.

6. A means for measuring oil flow through filter assembly. If this means is a flow meter, it should be located downstream from the test filter.

7. A filter assembly suitable for holding the element to be tested. By suitable, it is meant that the housing is of the proper size and empty flow rate to accommodate the element being tested. If there is a flow controlling orifice in the filter assembly, it should be of such a size to give within ±5% of the desired empty housing flow at the temperature specified. If there is a flow controlling device external to the filter housing, it shall be considered as a part of the filter assembly.

8. A pressure gage located as close as possible to the inlet of the filter housing. There should be a minimum of restriction to oil flow between the gage and the filter housing. Wherever practical, this pressure gage should be installed to measure pressure in an unfiltered quiescent location within the filter housing. A differential pressure gage should be used to measure accurately the pressure drop

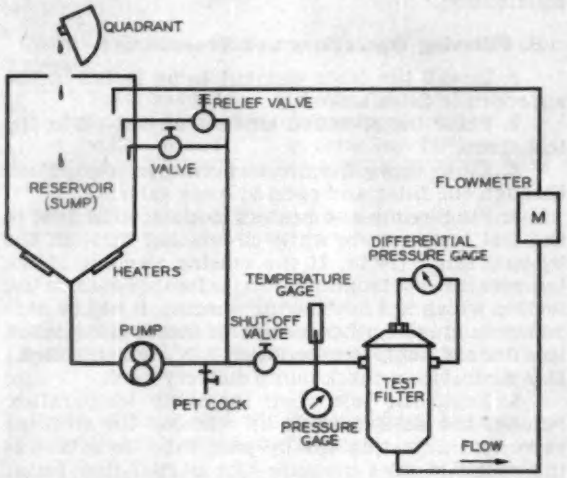


Fig. 5 — Schematic diagram of the testing system.

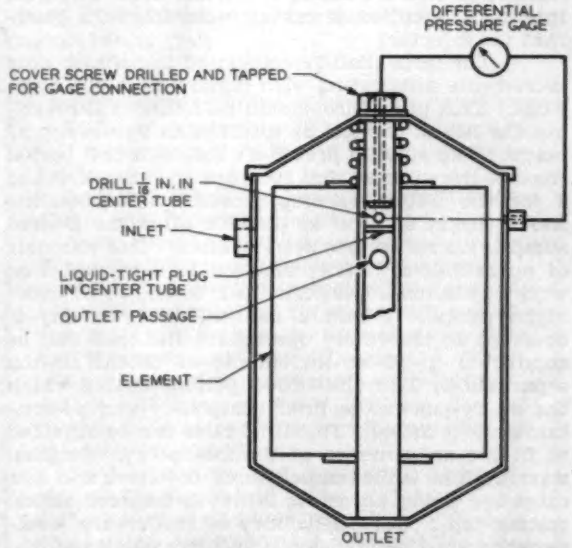


Fig. 6 — Arrangement for measuring pressure differential across the filter element.

across the actual filter element being tested. A typical set-up to accomplish this is shown in Fig. 6.

9. A temperature measuring means located so as to measure the temperature of the oil entering the filter housing.

10. A filter outlet to provide for return of the filtered oil to the sump and so arranged to provide minimum restriction to flow.

11. A contaminant addition system (quadrant or injector) as described in Paragraph II, C, D, E, and F.

12. A thermostat or other means of controlling the temperature of the oil entering the filter housing. Safeguards should be provided to prevent localized overheating in the event that oil flow through the filter drops sufficiently to affect heat distribution.

B. Filtering Operations and Procedures:

1. Install the filter element to be tested in the appropriate filter assembly.

2. Place the specified amount of test oil in the test sump.

3. Close shut-off valve to permit no circulation through the filter and open by-pass valve.

4. Start pump and heaters to allow oil to heat to the test temperature while circulating through the by-pass line. (Note: If the sensing element of the temperature controlling means is located outside the section which has flow during warmup, it will be necessary to provide other means for determining when the desired sump temperature has been reached.) It is desirable to check pump delivery here.

5. Begin the test when the sump temperature reaches the desired value by opening the shut-off valve and adjusting the by-pass valve to establish the specified inlet pressure (for partial-flow tests) or flow rate (for full-flow tests).

6. When proper conditions have been established, the addition of contaminant to the sump shall begin and the timing of the test shall start with this initial addition of contaminant from the quadrant (or injector).

7. The tests shall be conducted in definite time increments alternating with regular shut-down periods. This procedure should be followed throughout the life of the test as specified in Paragraph 12 below. The startup procedure for each test period shall be the same as that specified in Paragraph 3 to 6 for the initial warmup period. Actual testing should begin as soon as possible after the desired sump temperature has been reached. This schedule of operations is readily adapted to a normal 8-hr work day. Shut-down period can be the 16-hr overnight period. Where a continuous 24-hr day is observed in laboratory operations, the tests can be conducted in 22-hr increments of actual testing separated by 2-hr shut-down periods during which the oil by-passes the filter completely and no contaminant is added. This time ratio can be adjusted to fit the convenience of the laboratory. Original warmup time while temperatures, pressures and flow rates are being adjusted, is not considered actual testing time. For consistency of test results, comparisons must be made on a uniform time basis.

8. Record the following data at start of test and at the end of each test hour.

(a) Inlet oil pressure.

(b) Differential oil pressure.

(c) Oil flow rate through the filter.

(d) Oil temperature entering filter.

9. Draw oil samples from the sampling valve at the intervals specified in Paragraph IV A below. The total volume removed from the sampling valve at each sample period must equal the total volume introduced as contaminant concentrate during the between samples.

10. Contaminant slurry must be prepared in advance if the contaminant addition device is a quadrant. This slurry should be prepared as specified in Paragraph II D and E above.

11. Specified operating conditions should be maintained throughout the test by adjusting the by-pass valve and temperature control as necessary.

12. Test duration shall depend upon filter life (or capacity) and filtering efficiency. A laboratory bench test of approximately 66 to 88 hr is considered a good measure of filter performance. Low capacity will result in relatively shorter life, whereas, high capacity will result in relatively longer life. In the case of partial-flow filters, ultimate capacity can be considered reached when flow rate has dropped to the extent that established minimum efficiency can no longer be maintained. In the case of full-flow filters, ultimate capacity can be considered reached when element differential pressure has risen to a predetermined limiting value. Naturally the laboratory test life will be dependent upon the contaminant add rate employed and the relative size (or capacity) of the filter element.

13. To obtain a valid comparison between tests, the oil used must be identical in brand and formulation.

IV — Sampling, Analysis and Evaluation

A. Sampling of Oil for n-pentane analysis shall be dependent upon the operational schedule. Time of sampling shall be so arranged that no sample is taken within the first 2 hr of operation after a shut-down period. When working on a 24-hr day (around the clock) basis, samples shall be taken at least after each 11 hr of filter operation. When working on an 8-hr day (single shift) schedule, samples shall be taken at least after each 8 hr of filter operation. The oil sample shall be taken a maximum of 12 in. from the inlet to the test filter through a ⅛-in. pet cock. Before the sample is taken, the pet cock shall be opened and a minimum of 100 ml of fluid flushed through the pet cock. This flushing oil shall be returned to the test system sump (reservoir). The sample shall be obtained in a suitable container. Recommended container is a test tube, 20 mm in diameter and 6 in. long.

B. Sample Analysis shall comply with the following procedure:

1. Heat sample to 180 F or until sufficiently mobile to allow shaking of sample. The sample shall be shaken until the sediment is homogeneously suspended in the oil sample.

2. Weigh 10 g of sample into a preweighed centrifuge tube. Centrifuge tube preparation follows: Wash tube completely with a detergent. Rinse tube with water to remove suds. Rinse inside and outside of tube completely with acetone — during and

after rinsing, tube should not be touched by human hands. Place tube in a 105 ± 3 C oven for 45 min. Then put tube in desiccator to cool to room temperature. Weigh tube to the nearest milligram.

3. Fill tube to the 100-ml mark with n-pentane (or petroleum ether). The centrifuge tube referred to is the 100-ml size.

4. Shake tube well so contents are thoroughly mixed.

5. Centrifuge for 10 min at 10,000 *g*'s in high-speed centrifuge.

6. Decant all but 3 ml from the centrifuge tube without disturbing the precipitate.

7. Add 10 ml of n-pentane (or petroleum ether) to the centrifuge tube.

8. With a clean stiff wire, dislodge the precipitate and disperse it in the n-pentane (or petroleum ether).

9. Wash all insolubles adhering to the wire back into the tube using n-pentane (or petroleum ether) and filling the tube to the 50-ml mark.

10. Shake tube until mixture is homogeneous.

11. Centrifuge for 10 min at 10,000 *g*'s.

12. Decant supernatant liquid being careful not to disturb the precipitate.

13. Rinse outside of tube with acetone (during and after rinse, tube should not be touched by hands).

14. Place tube in an oven at 105 ± 3 C for 45 min.

15. Place tube in a desiccator until tube returns to room temperature.

16. Weigh tube to the nearest 1 mg. Calculate weight of solids in tube.

Note: The centrifuge tube referred to is of the 100-ml size.

C. An Alternate Method of Analysis employing millipore filter apparatus and technique may be used in lieu of the procedure of Paragraph B. Equipment may be purchased from Millipore Filter Corp., 39 Pleasant St., Watertown 12, Mass.

1. Accurately weigh 10 g of sample, after heating and shaking to assure homogeneous suspension of the solids content in the oil, in a convenient size beaker which has been cleaned and preweighed.

2. Add about 100 ml of n-pentane and mix thoroughly with a clean glass stirring rod.

3. Allow solids to settle for a few minutes and decant supernatant liquid slowly but steadily into the millipore filter funnel containing a preweighed millipore filter disc of type HA. Suction is applied to the millipore filter to aid filtration and should be controlled and not allowed to exceed the value recommended by Millipore Corp.

4. Repeat mixing and washing of sediment with additional n-pentane and pour onto the millipore filter. Wash all the solids onto the filter disc from the beaker and from the sides of the millipore funnel. Repeat this washing several times so that all solids and only solids remain on the millipore filter disc. Remove disc from funnel, dry in oven at 105 ± 3 C and weigh to nearest 1 mg. Calculate weight of solids on disc.

D. Evaluation of Test Results can best be accomplished by efficient recording and presentation of data. It is recommended that all data be recorded on a standard data sheet with spaces provided for all pertinent test information. Hourly readings and all observations should be included in such a format. For presentation purposes, data should be compiled in summary form containing tabulated test results and containing plotted curves on standard graph paper. Coordinates 10 × 10 to the ½ in. have been found convenient and satisfactory. Three separate graphs shall be drawn: efficiency versus hours-of-operation, n-pentane insolubles versus hours-of-operation, flow-rate versus hours-of-operation. Full-flow filters will not require the flow-rate versus hours-of-operation but will require pressure-differential versus hours-of-operation. These graphs may use the following scales.

1. On the abscissa for hours of operation, 20 hr per in.

2. On the ordinate for insolubles, 0.2% per in.

3. On the ordinate for efficiency, 20% per in.

4. On the ordinate for flow rate, 20 gpm per in.

5. On the ordinate for differential pressure, 10 psi per in.

Note: Filtering efficiency shall be calculated as follows:

$$E = \frac{\text{Total weight of contaminant solids added} - \text{Weight of contaminant solids in total test oil*}}{\text{Total weight of contaminant solids added}} \times 100$$

$$\left(\frac{\text{*Weight of total oil} \times \text{Per cent n-pentane insolubles}}{100}\right)$$

References

Federal Test Method Standard No. 791, Lubricants, Liquid Fuels and Related Products: Methods of Testing

F-F-351, Filters and Filter Elements; Lubricating Oil; Internal Combustion Engines

MIL-F-20707, Filter Elements, Fluid, Pressure; Oil, Full Flow

MIL-L-15016, Lubricating Oil, General Purpose

MIL-L-2104, Lubricating Oil, Internal Combustion Engine, Heavy Duty

To insure uniformity of results in this new test method, some sources of supply have been listed.

Section 7 (c) of the Rules and Regulations of the SAE Technical Board:

Every report approved and issued by the Board shall carry the following statement:

"All technical reports, including standards approved and practices recommended, are advisory only. Their use by anyone engaged in industry or trade is entirely voluntary. There is no agreement to adhere to any SAE Standard or SAE Recommended Practice, and no commitment to conform to or be guided by any technical report.

"In formulating and approving technical reports, the Board and its committees will not investigate or consider patents which may apply to the subject matter. Prospective users of the report are responsible for protecting themselves against liability for infringement of patents."

Jones Appointed Chairman of Aircraft Wheels, Brakes, and Axles Group

Ben. F. Jones

BEN. F. JONES, B. F. Goodrich Co., has been appointed chairman of SAE's Committee A-5, Aircraft Wheels, Brakes, and Axles. He succeeds W. H. DuBois, Bendix Aviation Products Division, who led the committee for 12 years.

Currently, A-5 members are seeking answers to high temperature wheel and brake problems encountered on new jet aircraft. Prevention of wheel and brake failures which endanger passengers as well as maintenance personnel is a prime objective. More specifically, studies are being made of brake overheating, tire blowouts, anti-skid systems and equipment, and minimum requirements for civil aircraft wheels and brakes as set forth in ARP 277C.

Jones follows his father in a tradition of active participation in technical committee work. B. Frank Jones, former chief engineer at Autocar Co. *and* White Motor Company's Truck Division, has served as a member of the Truck and Bus, Transportation and Maintenance, and Fuels and Lubricants Technical Committees. In 1940, Jones, Sr., was Vice President of the Truck and Bus Activity.

The next A-5 meeting will be held October 23 and 24 in conjunction with Committee A-12, Aircraft Landing Gear Shock and Control Mechanisms. A tour of airline maintenance facilities is planned.

70 New, Revised AMS's Issued, Most Since 1951

SEVENTY Aeronautical Material Specifications (27 new, 43 revised) have been released by the Society. This marks a significant high since 1951 when, in June, a record 108 were released.

Complete sets of the AMS's listed below are available in loose-leaf form to supplement those previously issued. Each set, along with a revised Index, may be obtained from SAE Headquarters for $8.85.

AMS 2261C, Tolerances, Nickel, Nickel Base, and Cobalt Base Alloy Bars and Forging Stock

AMS 2471, Anodic Treatment for Aluminum Base Alloys, Sulfuric Acid Process

AMS 2635, Radiographic Inspection

AMS 2668, Silver Brazing, Flexible Metal Hose — 400 F Max Operating Temperature

AMS 2669, Silver Brazing, Flexible Metal Hose — 800 F Max Operating Temperature

AMS 3155, Oil, Fluorescent Penetrant, Solvent Soluble

AMS 3156, Oil, Fluorescent Penetrant, Water Soluble

AMS 3160B, Solvent, Petroleum

AMS 3212J, Synthetic Rubber, Aromatic Fuel Resistant (55–65)

AMS 3213G, Synthetic Rubber, Aromatic Fuel Resistant (75–85)

AMS 3214G, Synthetic Rubber, Aromatic Fuel Resistant (35–45)

AMS 3215G, Synthetic Rubber, Aromatic Fuel Resistant (65–75)

AMS 3220B, Synthetic Rubber (55–65)

AMS 3270D, Synthetic Rubber Sheet, Cotton Fabric Reinforced, Weather Resistant — Chloroprene Type

AMS 3273, Synthetic Rubber Sheet, Nylon Fabric Reinforced, Feather Resistant — Chloroprene Type

AMS 3274B, Synthetic Rubber Sheet, Nylon Fabric Reinforced, Aromatic Fuel Resistant

AMS 3338A, Silicone Rubber, Extreme Low Temperature Resistant (75–85)

AMS 3386, Hose, Synthetic Rubber, Aircraft Fueling, Textile Reinforced — Collapsing

AMS 3387, Hose, Synthetic Rubber, Aircraft Fueling, Textile Reinforced — Noncollapsing

AMS 3388, Hose, Synthetic Rubber, Aircraft Fueling, Single Wire Braid Reinforced — Noncollapsing

AMS 3389, Hose, Synthetic Rubber, Aircraft Fueling, Double Wire Braid Reinforced — Noncollapsing

AMS 3411, Flux, Silver Brazing, High Temperature

AMS 3581, Plastic Castings, Methyl Methacrylate, Heat Resistant

AMS 3590A, Plastic Sheet, Copper Faced, Paper Reinforced Phenol-Formaldehyde

AMS 3601A, Plastic Sheet, Copper Faced, Glass Fabric Reinforced Epoxy Resin

AMS 3608, Plastic Sheet, Methyl Methacrylate, General Purpose

AMS 3609, Plastic Sheet, Methyl Methacrylate, Heat Resistant

AMS 3627, Plastic Moldings and Extrusions, Methyl Methacrylate, Heat Resistant

AMS 3736, Potting Compound, Epoxy, Filled, 25–30 CTE, 175 HDT, Room Temperature Cure

AMS 3737, Potting Compound, Epoxy, Unfilled, 35–40 CTE, 160 HDT, Room Temperature Cure

AMS 4021B, Aluminum Alloy Sheet and Plate, Alclad, 1Mg-0.6Si-0.25Cu-0.25Cr (Alc 6061-0)

AMS 4022B, Aluminum Alloy Sheet and Plate, Alclad, 1Mg-0.6Si-0.25Cu-0.25Cr (Alc 6061-T4)

AMS 4023B, Aluminum Alloy Sheet and Plate, Alclad, 1Mg-0.6Si-0.25Cu-0.25Cr (Alc 6061-T6)

AMS 4028, Aluminum Alloy Sheet and Plate, 4.5Cu-0.8Si-0.8Mn-0.5Mg (2014-0)

AMS 4029, Aluminum Alloy Sheet and Plate, 4.5Cu-0.8Si-0.8Mn-0.5Mg (2014-T6)

AMS 4041F, Aluminum Alloy Sheet and Plate, Alclad, 4.5Cu-1.5Mg-0.6Mn (Alclad 2024; -T3 Sheet, -T4 Plate)

AMS 4042E, Aluminum Alloy Sheet and Plate, Alclad, 4.5Cu-1.5Mg-0.6Mn (Alclad 2024-T36)

AMS 4048C, Aluminum Alloy Sheet and Plate, Alclad, 5.6Zn-2.5Mg-1.6Cu-0.25Cr (Alclad 7075-0)

AMS 4049C, Aluminum Alloy Sheet and Plate, Alclad, 5.6Zn-2.5Mg-1.6Cu-0.25Cr (Alclad 7075-T6)

AMS 4230C, Aluminum Alloy Castings, Sand, 4.5Cu (195-T4), Solution Treated

AMS 4286A, Aluminum Alloy Castings, Permanent Mold, 7Si-0.3Mg (356-T51)

AMS 4375B, Magnesium Alloy Sheet and Plate, AZ31B-0

AMS 4376A, Magnesium Alloy Plate,

AZ31B-H26

AMS 4377, Magnesium Alloy Sheet and Plate, AZ31B-H24

AMS 4420G, Magnesium Alloy Castings, Sand, 6A1-3Zn (AZ63A-F), As Cast

AMS 4422H, Magnesium Alloy Castings, Sand, 6A1-3Zn (AZ63A-T4), Solution Treated

AMS 4424F, Magnesium Alloy Castings, Sand, 6A1-3Zn (AZ63A-T6), Solution and Precipitation Treated

AMS 4434F, Magnesium Alloy Castings, Sand, 9A1-2Zn (AZ92A-T6), Solution and Precipitation Treated

AMS 4437, Magnesium Alloy Castings, Sand, 8.7A1-0.7Zn (AZ91C-T6), Solution and Precipitation Treated

AMS 4442A, Magnesium Alloy Castings, Sand, 3.3Ce-2.5Zn-0.7Zr (EZ33A-T5), Aged

AMS 4443A, Magnesium Alloy Castings, Sand, 4.5Zn-0.7Zr (ZK51A-T5), Aged

AMS 4555C, Brass Tubing, Seamless, 68Cu-31Zn, Light Annealed

AMS 4558B, Brass Tubing, Seamless, 66Cu-32Zn-1.6Pb, Drawn Temper

AMS 4610H, Brass, Free Cutting, 61.5Cu-3Pb-35.5Zn, Half Hard

AMS 4611C, Brass, Naval, 60.5Cu-0.8Sn-38.7Zn, Half Hard

AMS 4612D, Brass, Naval, 60.5Cu-0.8Sn-38.7Zn, Hard Temper

AMS 4615C, Silicon Bronze, 95.5Cu-3.2Si, Hard

AMS 4616B, Silicon Bronze, 92Cu-3.2Si-2.8Zn-1.5Fe

AMS 4630E, Aluminum Bronze, 90Cu-8.5A1, Soft

AMS 4631C, Aluminum Bronze, 90.5Cu-7.5A1-1.9Si

AMS 4632C, Aluminum Bronze, 90Cu-8.5A1, Hard

AMS 4771, Brazing Alloy, Silver, 50Ag-16Cd-15.5Zn-15.5Cu-3Ni

AMS 4929, Titanium Alloy, 5.4A1-1.4Cr-1.3Fe-1.25Mo, Annealed — 135,000 psi Yield

AMS 5506A, Steel Sheet and Strip, Corrosion and Moderate Heat Resistant, 13Cr (0.30-0.40C) (SAE 51420)

AMS 5525A, Steel Sheet and Strip, Corrosion and Heat Resistant, 15Cr-26Ni-1.3Mo-2.1Ti-0.3V

AMS 5665C, Alloy, Corrosion and Heat Resistant, Nickel Base-15.5Cr-8Fe

AMS 5667E, Alloy, Corrosion and Heat Resistant, Nickel Base — 15.5Cr-7Fe-2.5Ti-1(Cb-Ta)-0.7Al

AMS 6423, Steel, 0.9Cr-0.75Ni-0.52Mo-B (0.40–0.46C)

AMS 6461, Steel Wire, 0.95Cr-0.2V (0.28–0.33C) (SAE 6130)

AMS 7283, Gaskets, Type XX Engine Accessory Drive, Corrosion Resistant Steel Screen Reinforced, Controlled Performance

CRC Releases Eight New Reports

THE following Coordinating Research Council reports have been released for distribution and are available from SAE Special Publications Department.

(This is a complete list of CRC reports released since publication of the listing on page 98 of the December, 1957, SAE Journal.)

FUELS

Aviation-Pumpability

CRC 318 — "Low-Temperature Pumping Characteristics and Physical Properties of Aviation Gas Turbine Fuels."

CRC 319 — "Supplementary Report on Low-Temperature Pumping Characteristics of Aircraft Turbine Fuels."

CRC 320 — "Report of the Turbine Low-Temperature Pumpability Group."

Storage Stability

CRC 327 — "Jet Fuel Storage Stability."

MOTOR

CRC 314 — "Grab Sampling and Analysis Techniques for Engine Exhaust Gas."

(CRC 314 contains the following research techniques: "Research Technique for Sampling Gasoline-Engine Exhaust Gas" — CRC Designation E-16-857; "Research Technique for Collecting Exhaust Gas Samples from Moving Automobiles" — CRC Designation E-17-857; "Research Techniques for Collecting Exhaust Gas Samples from Moving Automobiles for Oxides of Nitrogen Determination" — CRC Designation E-18-857; "Research Technique for Determination of Water Content of Exhaust Gases" — CRC Designation A-1-857; "Research Technique for Determination of Oxides of Nitrogen in Gaseous Combustion Products (Phenol Disulfonic Acid Technique)" — CRC Designation A-2-857; "Research Technique for Determination of Total Organics in Gasoline-Engine Exhaust Gases by Mass Spectrometry" — CRC Designation A-3-857; "Research Technique for Infrared Determination of Carbon Monoxide, Carbon Dioxide, and Hydrocarbons in Automotive Exhaust" — CRC Designation A-4-857; "Research Technique for Determination of Total Organics in Exhaust Gases (Combustion Orsat Technique)" — CRC Designation A-5-857.)

Motor-Exhaust Gas

CRC 321 — "A Gas Chromatographic Technique for Exhaust Gas Analysis" — Interim Report No. 1 (December, 1957).

Motor-Volatility

CRC 328 — "Trouble Spot Survey of Hot Fuel Handling Problems — Summer, 1954."

LUBRICANTS

Aircraft

CRC 317 — "Development of a Laboratory Technique for Determining Rust-Preventive Properties of Lubricating Greases."

(CRC 317 contains the following research techniques: "Research Technique for Determining Corrosion on Grease-Coated Ball Bearings" — CRC Designation L-34; and "Research Technique for Determining Rust-Preventive Properties of Lubricating Greases in the Presence of Free Water" — CRC Designation L-41-957.)

Engine Oils, Motor

CRC 315 — "Varnish and Sludge Studies in Stop-and-Go Operation — A Progress Report."

EQUIPMENT

See CRC 314 and 321 listed above.

SAE Moves into Mobile Home—Travel Trailer Area

SAE's new Mobile Home-Travel Trailer Technical Committee will meet the growing need for standards in areas of product construction and design which affect user health and safety.

Members drew up a scope covering the development of standards and recommended practices for "mobile homes and travel trailers, their components and accessories" at a recent Detroit meeting called by Chairman Rex Anderson, ABC Coach Co. Minimum tests, installation and performance requirements based on accepted engineering principles are a prime objective.

Endorsed by Technical Board

Technical Board sanction of the project came last spring as the result of a request made by an industry group led by Earl Swett, president of the Mobile Home Mfg. Assn.

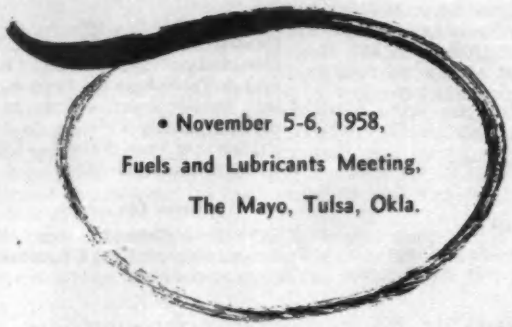
Three subcommittees have been formed. Their names and respective chairmen are:

Electrical Systems — R. E. Korthals, Anderson Coach Co.

Heating Systems — D. G. Longworth, Raymond Products Co.

Plumbing Systems — M. E. Wichersham, American Coach Co.

SAE national meetings



- November 5-6, 1958, Fuels and Lubricants Meeting, The Mayo, Tulsa, Okla.

- January 12-16, 1959, Annual Meeting, and Engineering Display, Sheraton-Cadillac and Statler Hotels, Detroit, Mich.

- March 16-18, 1959, National Passenger Car, Body and Materials Meeting, The Sheraton-Cadillac, Detroit, Mich.

- March 19-20, 1959, National Production Meeting, The Sheraton-Cadillac, Detroit, Mich.

- March 31-April 3, 1959, National Aeronautic Meeting, Aeronautic Production Forum, and Aircraft Engineering Display, Hotel Commodore, New York, New York

- June 14-19, 1959, Summer Meeting, Chalfonte-Haddon Hall, Atlantic City, N. J.

- August 10-13, 1959, National West Coast Meeting, Hotel Georgia, Vancouver, B. C., Can.

- September 14-17, 1959, National Farm, Construction, and Industrial Machinery Meeting, Production Forum, and Display, Milwaukee Auditorium, Milwaukee, Wis.

- October 5-10, 1959, National Aeronautic Meeting, Aircraft Manufacturing Forum, and Aircraft Engineering Display, The Ambassador, Los Angeles, Calif.

- October 26-28, 1959, National Transportation Meeting, La Salle Hotel, Chicago, Ill.

- October 27-28, 1959, National Diesel Engine Meeting, La Salle Hotel, Chicago, Ill.

- October 28-30, 1959, National Fuels and Lubricants Meeting, La Salle Hotel, Chicago, Ill.

SAE SECTION MEETINGS

BALTIMORE

October 22 . . . "Maryland Style Oyster Roast" at the Alcazar, Cathedral and Madison, Baltimore. Time: 6:00 p.m. to 10:00 p.m. $6.00 per person.

CENTRAL ILLINOIS

October 27 . . . P. J. Larsen, assistant to vice president; A. P. Boysen, district engineer, Chicago; G. R. Carter, directing manager, Chicago, American Bridge Division, U.S. Steel Corp. "Mackinac Bridge." Dinner 6:30 p.m. Meeting 7:45 p.m. Special Feature: Color Movie "Mackinac Bridge Diary."

CHICAGO

October 14 . . . Dr. W. A. Orr, senior aerophysics group engineer, Convair. "Properties of Space Orbits." Dinner 6:45 p.m. Meeting 8:00 p.m. Special Feature: Social Half Hour 6:15 p.m. to 6:45 p.m.

November 11 . . . Joint meeting — Truck and Bus, and Transportation and Maintenance.

CLEVELAND

October 12 . . . Production Activity Meeting.

November 10 . . . Truck and Bus Activity Meeting.

COLORADO

October 13 . . . E. T. Mabley, truck applications engineer, Allison Division, GMC. "Automatic Transmission for Trucks." General Motors Training Center, 2701 S. Dahlia Street, Denver. Dinner 6:30 p.m. Meeting 8:00 p.m.

DETROIT

October 20 . . . Junior Group. Field trip tour of Hardware Accessory Division Plant, Ford Motor Co., Rawsonville, Mich. Meeting 2:00 p.m.

November 3 . . . Tour of Chevrolet Engineering Center and Fisher Body Division, GMC, Warren, Mich. Time: 3:00 p.m. to 6:00 p.m. James E. Goodman, vice president and group executive, Body and Assembly Divisions Group, GMC. "Silent Salesmanship." E. N. Cole, general manager, Chevrolet Motor Division, GMC. "Good is Not Good Enough." Dinner 6:00 p.m. Meeting 8:00 p.m. $3.25 per plate.

INDIANA

October 16 . . . SAE President William K. Creson. "Tomorrow's Engineer." Ralph Kress, chief engineer, LeTourneau-Westinghouse Co. "The New LeTourneau-Westinghouse, Off-Hi-way Truck." Dinner 7:00 p.m. Meeting 8:00 p.m.

October 17 . . . Fort Wayne Division. SAE President William K. Creson, "Tomorrow's Engineer."

KANSAS CITY

October 15 . . . "Atomic Power Plant," Westinghouse. War Memorial Bldg. #2, Linwood & Paseo. Dinner 7:00 p.m. Meeting 8:00 p.m.

November 3 . . . SAE President William K. Creson. "Steering of Modern Automotive Vehicles."

METROPOLITAN

October 16 . . . Darl F. Caris, engineer-in-charge, Power Development Section, GMC. "A New Look at High Compression Engines." Henry Hudson Hotel, 57th St. & Ninth Ave., NYC. Meeting 7:45 p.m.

November 6 . . . Dr. Joseph W. Siry, head, theory and analysis branch of the Project Vanguard, U.S. Naval Research Laboratory, Washington, D. C. "Exploration of Space by Means of Satellites." Garden City Hotel, Garden City, L. I., N. Y. Meeting 7:45 p.m.

November 13 . . . Sperry Award Dinner-Meeting. This will be a joint meeting with ASME. Dr. Heinz Nordhoff, director-general, Volkswagenwerke, Wolfsburg, Germany. "The Past and Future of the Volkswagen." Brass Rail Restaurant, Fifth Ave., between 43rd and 44th Sts., NYC. Cocktails 5:30 p.m. Dinner 6:30 p.m. Meeting 7:45 p.m. Dinner price $3.95 per person. Special Feature: The Elmer A. Sperry Award for 1958 made to Dr. Ferdinand Porsche (in memoriam), to Dr. Heinz Nordhoff and their co-workers at the Volkswagenwerke. Award will be presented to Dr. Nordhoff by William Littlewood, American Airlines, Inc.

MONTREAL

October 20 . . . G. A. Smith, styling engineer, GMC Overseas Operations. "Variegated Body Design." Mount Royal Hotel. Dinner 7:00 p.m. Meeting 7:45 p.m. Special Feature: Reception 6:15 p.m.

NORTHWEST

October 17 . . . E. T. Mabley, truck application engineer, Allison Division, GMC. "Automatic Transmissions for Trucks." Hotel Stewart, 2nd and Stewart Sts., Seattle. Dinner 7:00 p.m. Meeting 8:00 p.m. Special Feature: Film on 1958 Indianapolis 500 Mile Race.

PHILADELPHIA

November 12 . . . Student Night. R. G. McMahan, Product Application Division, Socony Mobil Oil Co. "Engineering Aspects of the Indianapolis 500 Mile Race." The Engineers' Club, 1317 Spruce St., Philadelphia. Cocktails 6:00 p.m. Dinner 6:30 p.m. Meeting 7:45 p.m. Special Feature: Dr. LeRoy A. Brothers, Dean, College of Engineering, Drexel Institute of Technology will be the Coffee Speaker.

PITTSBURGH

October 28 . . . O. C. Kebernick, assistant marketing manager, Atomic Power Department, Westinghouse Electric

Corp. "The Cooperative Approach to Atomic Power." Mellon Institute of Industrial Research. Dinner 6:30 p.m. Meeting 8:00 p.m.

SOUTHERN CALIFORNIA

October 13 . . . Wallace Linville, automotive engineer, County of Los Angeles. "A Status Report on Automotive Smog Controls." Rodger Young Auditorium, 936 W. Washington Blvd., Los Angeles. Dinner 6:30 p.m. Meeting 8:00 p.m.

SOUTHERN NEW ENGLAND

November 5 . . . Joseph Statsinger, assistant chief engineer, Missile Guidance, American Bosch Arma Corp. "Inertial Guidance." American Bosch Arma Cafeteria, Springfield, Mass. Dinner 6:45 p.m. Meeting 8:00 p.m. Special Feature: Cocktail Hour.

SPOKANE-INTERMOUNTAIN

October 14 . . . R. M. Schaefer, manager, Engineering Transportation Division, GMC. "Heavy Duty Automotive Transmission." Desert Caravan Inn, Spokane. Dinner 6:30 p.m. Meeting 8:00 p.m.

TEXAS

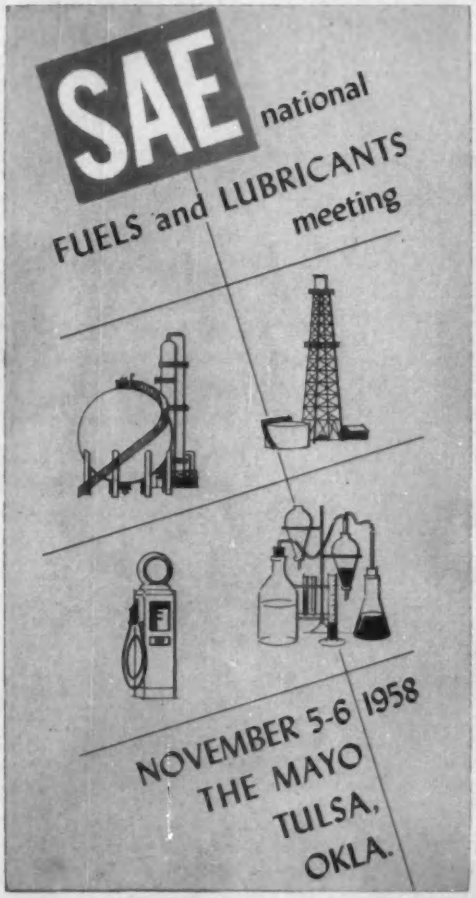
October 10 . . . Capt. R. W. Truax, U.S. Navy, senior member of advisory group to deputy director of U.S. Government's Advanced Research Project Agency. "Military and Scientific Missions in Space." Dallas. Dinner 7:30 p.m. Meeting 8:30 p.m.

TEXAS GULF COAST

October 20 . . . L. T. Flynn, engineering consultant, fleet and sales department, Truck and Coach Division, GMC. "Fitting the Truck to the Job." Houston Engineering and Scientific Society Bldg., 2615 Fannin St., Houston. Dinner 6:30 p.m. Meeting 7:45 p.m.

WASHINGTON

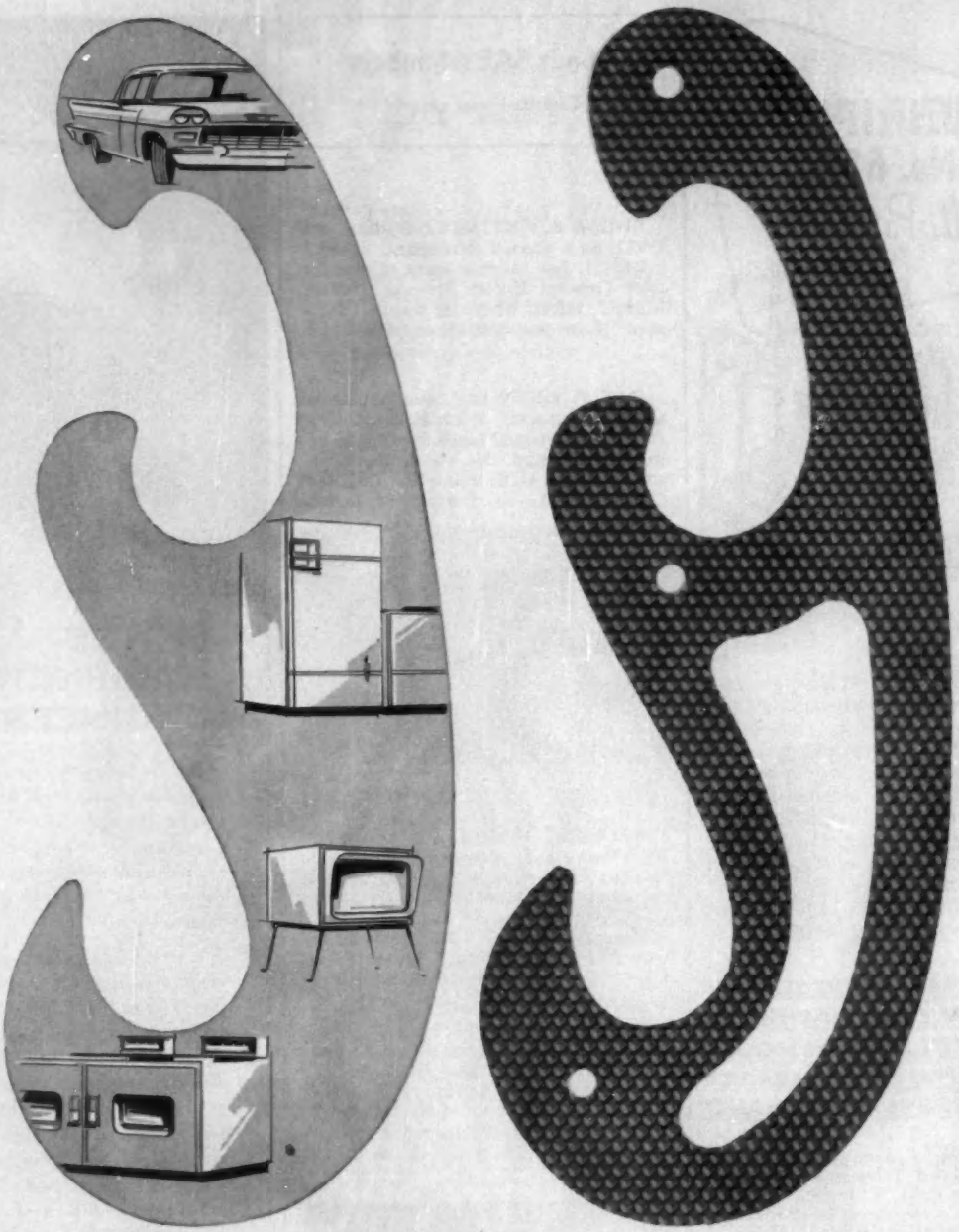
October 21 . . . Field trip to Aberdeen Proving Grounds. Transportation will be provided. Departing Washington 8:00 a.m. Special Feature: Demonstration of Army transportation equipment.



sessions will

cover such varied topics as:

- Pros and cons of antiwear additives
- Volatility tolerance of passenger cars in the mountains
- Abnormal combustion in high-compression single-cylinder engines
- Customers' antiknock ratings
- Multipurpose lab engine test
- Motor oil performance in taxicabs
- Low-temperature engine deposits — Aberdeen fleet test results



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About SAE Members

Continued from page 95

EDGAR R. WHITNEY has joined the USAF as a second lieutenant, student pilot. He has taken a leave of absence from General Motors Proving Ground, Milford, Mich., where he was Jr. Engineer, Noise and Vibration Laboratory.

RAY P. DUNN has been appointed technical director of Lindberg Melting Furnace Division, Lindberg Engineering Co., Chicago. He was formerly associated with U. S. Reduction Co., East Chicago, Ind., as director of metallurgy.

Dunn

Earle

SHEROD L. EARLE has been made supervisory marine power plant development engineer, head of the Internal Combustion Engine Laboratory at the U. S. Navy's Engineering Experiment Station at Annapolis. He was formerly mechanical engineering head, Small Diesel Branch of the ICE Laboratory.

HAROLD E. FRANCIS has been named chief project engineer of Chandler-Evans, Division of Pratt & Whitney Co., Inc., West Hartford, Conn. He was previously senior staff engineer with Chandler-Evans.

Francis

Michel

CLARENCE A. MICHEL, who has been general manager of Guide Lamp Division of General Motors Corp., Anderson, Ind., since 1941, plans to retire Dec. 31. He has been with GMC for 43 years. Michel is a past-chairman of the SAE Lighting Committee.

Continued on page 113

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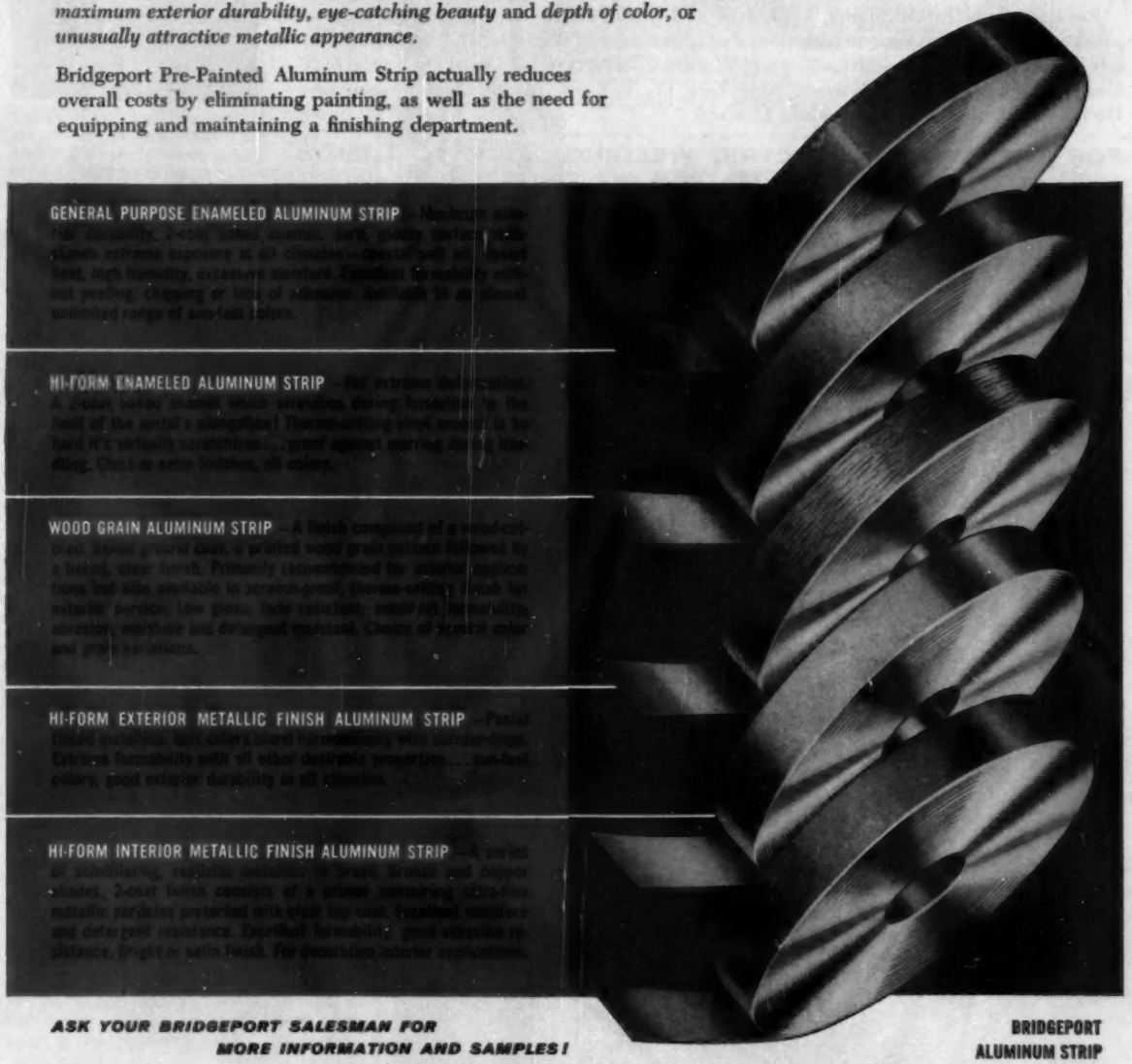

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About SAE Members

Continued from page 110

WALTER E. JOMINY, who retired in June as Chrysler Corp.'s chief metallurgist, has been named by The American Society for Metals to serve as secretary for the 1958–1960 term. Jominy is a former president of that society and also 1956 SAE vice-president representing Engineering Materials Activity.

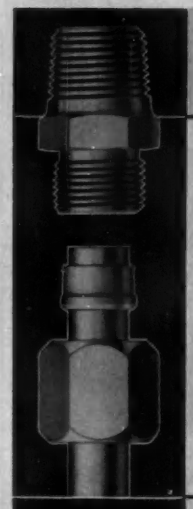
Jominy Ainsley

WALTER G. AINSLEY of Sinclair Research Laboratories, Inc., has been named coordinator in research between Sinclair and the automotive industry. He will be in charge of a new office established in Detroit. Prior to his new assignment, Ainsley was Sinclair's director of engine laboratories, a division of Sinclair Research. He joined the organization in 1929. In his early years with the company, he organized and supervised various refinery engine testing laboratories. He was 1952 SAE vice-president representing Diesel Engine Activity.

ORMOND E. HUNT has been sworn in by Postmaster General Arthur E. Summerfield as a member of the Post Office Department Advisory Board. Composed of private citizens, the Board is consulted on service and policy changes. Hunt, who is a director of General Motors Corp., contributed discussion of early automobile testing methods to a technical session at Detroit Section's Summer Meeting at White Sulphur Springs last month. He described the conditions and requirements which led to establishment of the large proving grounds, now common in the industry.

E. B. OGDEN, vice-president of Consolidated Freightways, Inc., announced the opening of offices of the Equipment and Methods Development Department in Avon Lake, Ohio. Formerly these offices were located in Portland, Ore.

Continued on page 114



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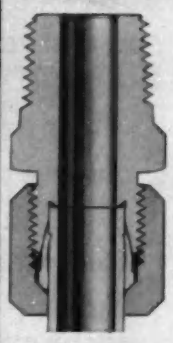

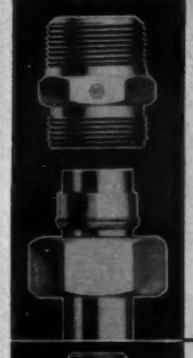

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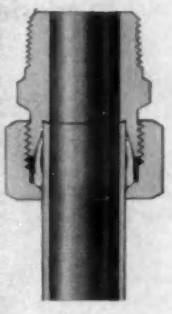

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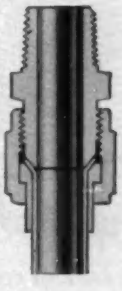

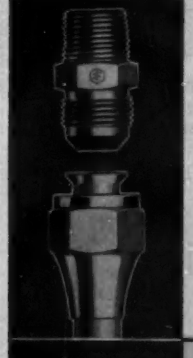

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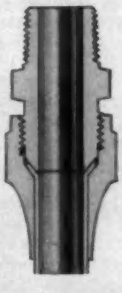

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is FINE enough to Flow through the newly designed Cooling System and Car Heater tubes (23/1000 to 70/1000 inch) in modern cars.

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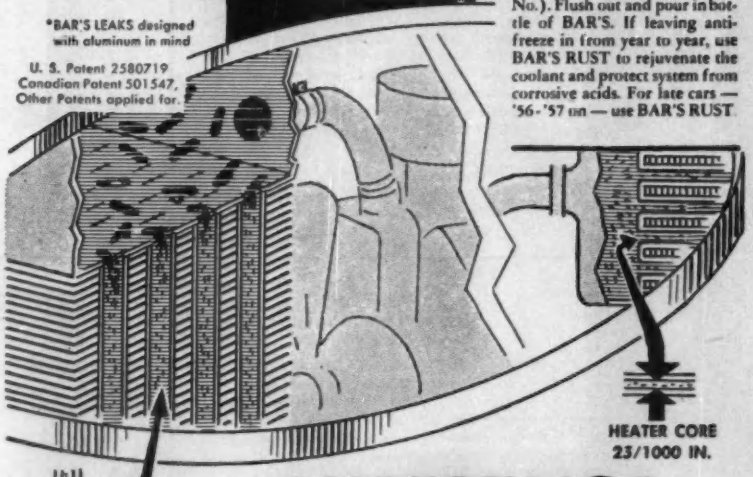
● For top engine performance, use BAR'S LEAKS or its affiliate, BAR'S RUST (same Pat. No.). Flush out and pour in bottle of BAR'S. If leaving anti-freeze in from year to year, use BAR'S RUST to rejuvenate the coolant and protect system from corrosive acids. For late cars — '56-'57 on — use BAR'S RUST.



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Only BAR'S LEAKS meets the cooling system specifications of every automobile manufacturer as to fineness of ingredients and required protection.

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About SAE Members

Continued from page 113

GILBERT WILKES III will work with original equipment manufacturers on engineering problems and sales development for France Packing Co. of Philadelphia. Previously, he was with the Koppers Co. in Baltimore, Md., as project and development engineer.

Wilkes Wilson

GROVER C. WILSON is now teaching engineering at California Western University, a recently established college in San Diego, Calif. In addition, he will continue with Ethyl Corp., from which he has just retired, in a limited consulting capacity. For many years, Wilson was staff assistant, Research Division, at Ethyl. He is a past SAE vice-president representing Diesel Engine Activity, and is active in many technical committee projects. He moved to the West Coast late in August. His new address is 617 Savoy St., San Diego, Calif.

Obituaries

FRANK P. GILLIGAN . . . (M'17) . . . had been consulting metallurgist, Henry Souther Engrg. Co. . . . active in the SAE Iron and Steel Technical Committee . . . died Sept. 5 . . . born 1884.

RAYMOND T. LEWIS . . . (M' 53) . . . had been manager, Commercial Aviation Systems Engineering Subsection, General Electric Co. . . . died March 31 . . . born 1909.

GEORGE VERNON ROARK . . . (M'54) . . . lubrication technologist for 29 years with Texas Oil Co. . . . died Aug. 22 . . . born 1899.

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Continental Motors, power specialists since 1902, present the Continental Continuous-Flow Fuel Injection System as the greatest advance in its field in many, many years. Designed, developed, and built exclusively by Continental, and proved in well over a million miles of trouble-free flight, it brings an entirely new concept of performance, safety, dependability and economy to flying, vastly broadening the usefulness of airplanes.

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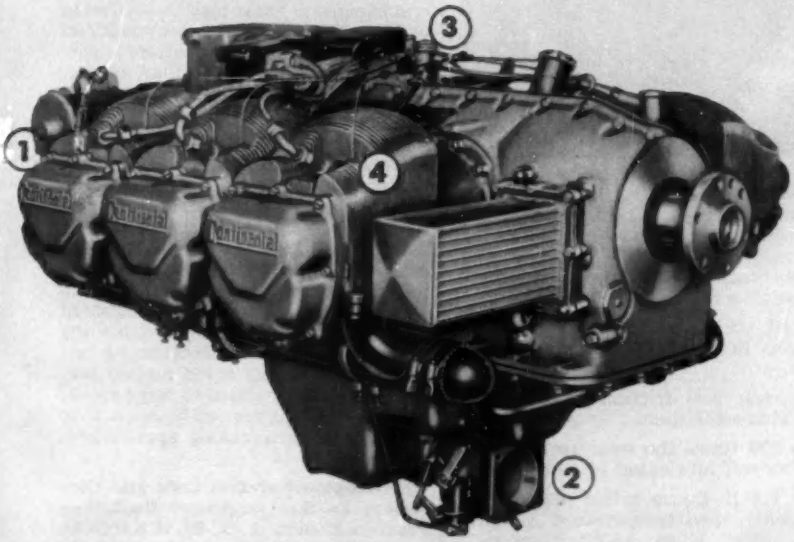
no more running parts than carburetor fuel system! Very close tolerances eliminated — no plungers — nothing to get out of adjustment. It's as simple as this:



1. Conventional type fuel pump pressurizes fuel.
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3. Manifold valve divides fuel uniformly to all cylinders. NO RUNNING PARTS.
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★ **BETTER ACCELERATION,** with none of the characteristic flat spots just above idle. Fuel doesn't have to travel from a distant carburetor; it's right at the cylinder all the time.

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Investigate this new bearing material for the potential improvements it offers in your products. Ask your bearing manufacturer or write for engineering brochure to

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FLUON, I.C.I. Trademark

United States Gasket *Plastics Division of* **GARLOCK**

Briefs of SAE PAPERS

Continued from page 6

G. LOOFBOURROW. Paper No. 62D presented June 1958, 13 p. Data indicate that risk of dangerous to fatal injury is 30% less in crashes of 1956 models; progress is due to devices such as safety steering wheel, door latches, etc.; Automotive Crash Injury Research Program includes studies of human engineering and car-driver-road relationship; communication of information to driver; transmission of driver decisions to car controls, and automatic control devices.

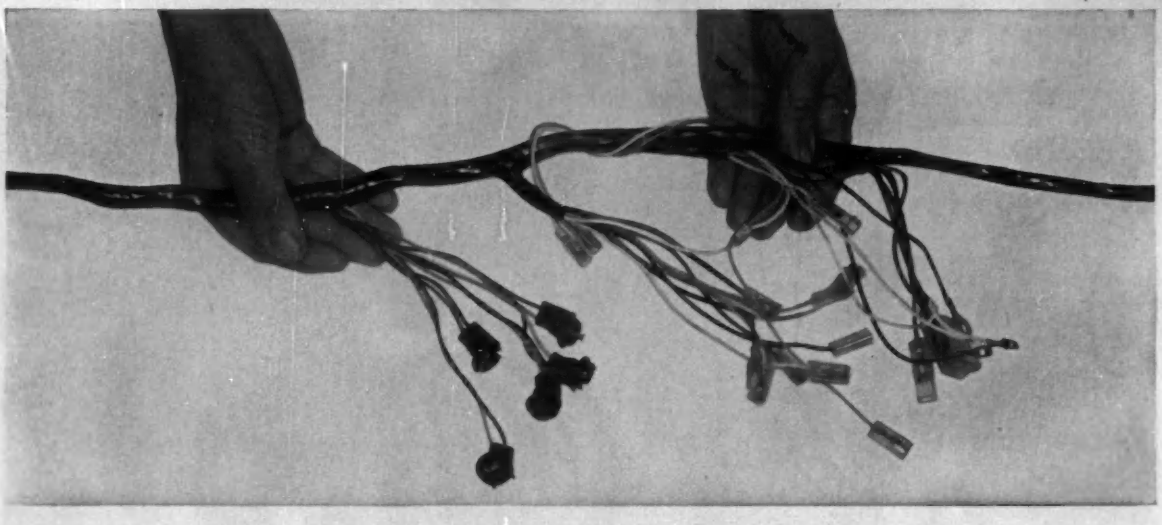
Comprex Diesel Supercharger, M. BERCHTOLD. Paper No. 63A presented June 1958, 19 p. Comprex developed by I-T-E Circuit Breaker Co., fulfills same task as turbocharger, using, however, different phenomena to perform function; unit has one rotating element in which both compression and expansion takes place; application to high duty vehicles as 4-cycle diesel engine supercharger; measured performance map of Caterpillar engine; advantages and disadvantages.

How Diesel Engine Rates Itself, W. J. McCULLA. Paper No. 64A presented June 1958, 20 p. Rating based upon theoretical considerations and approval of engine itself; factors in rating considerations include knowledge of application and its nature, intermittent or continuous; other factors which differ for naturally aspirated engines or those with mechanically driven blower and turbocharged engines, in particular speed limited turbocharger; tests related to rated speed; performance curves with respect to tractor and earthmoving applications.

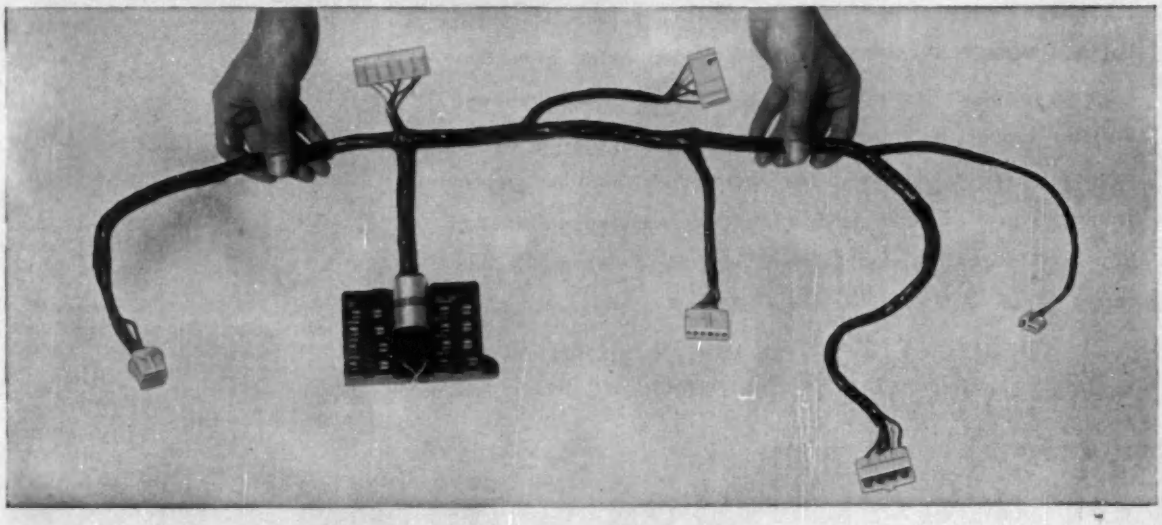
Development of Test Code and Correction Factors for Diesel Engines—Progress Report, A. K. BLACKWOOD, M. A. ELLIOTT. Paper No. 64B presented June 1958, 8 p. Tentative draft of code being prepared by SAE Diesel Engine Test Code Committee, indicates reasons behind some of provisions and procedures where appropriate.

Interstate Highway System, D. W. LOUTZENHEISER. Paper No. 66A presented June 1958, 13 p. Construction being developed as part of continuing Federal aid program; basis of program and how it operates; Interstate design controlled access; scope and progress of total program.

Continued on page 119



GOOD / *Wiring harness unites many individual cables*



BETTER / *Packard wiring system reduces end-product cost*

Packard Electric engineers, like the clients with whom they work, are never satisfied. They strive continually to make their products less expensive and easier to use. Now they've made it possible for the already efficient automotive wiring harness to become an even more complete sub-assembly! For *less* than it would cost to purchase components separately, they can usually be supplied already connected as an integral part of the harness. And single terminals can be replaced by "Snap Fast" multiple-connectors, fuse blocks and other cost-saving components.

If your present wiring harnesses do not include these cost-saving advantages, ask Packard engineers to help work out modern wiring *systems* for you. Packard Electric, the world's largest producer of automotive wiring systems, has sales and engineering offices in Detroit, Chicago, and Oakland, California.

Packard Electric

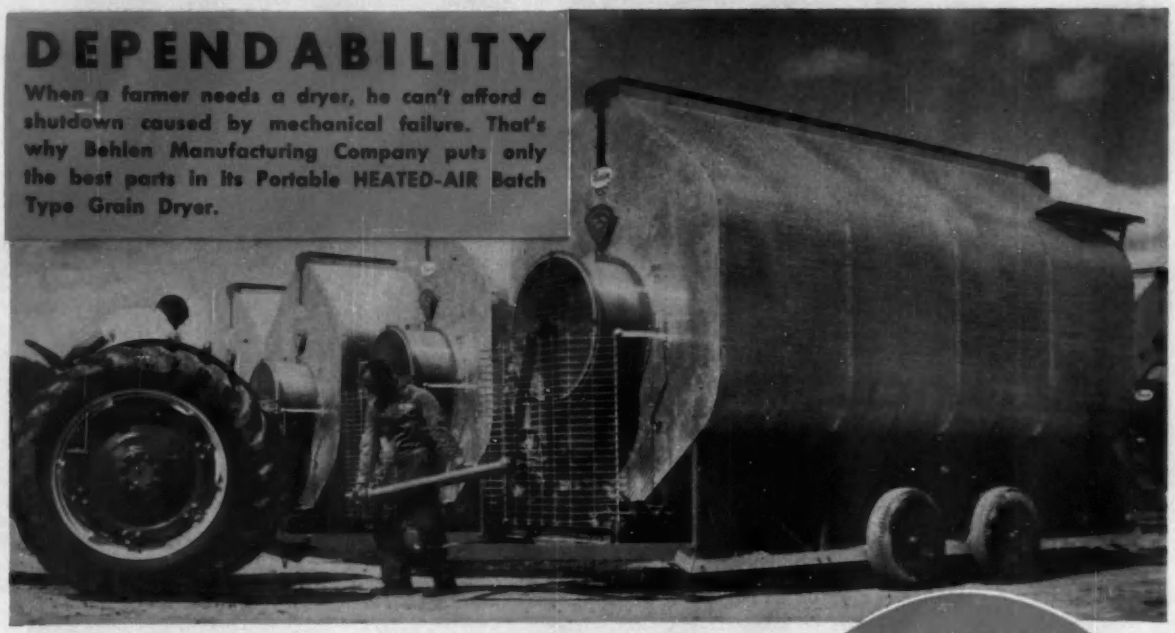
Warren, Ohio

GM GENERAL MOTORS

"Live Wire" division of General Motors

DEPENDABILITY

When a farmer needs a dryer, he can't afford a shutdown caused by mechanical failure. That's why Behlen Manufacturing Company puts only the best parts in its Portable HEATED-AIR Batch Type Grain Dryer.



Behlen engineers conducted exhaustive tests before selecting the MECHANICS driveline for their 500-bushel dryer. Its safety shield has true ROLLER BEARINGS to provide larger contact area, distributing the load, and avoiding trouble caused by ball bearings bursting through the shield. There are no welds—leaving longer overlap of shield tubes (with the same length shaft) for greater strength. Farm equipment manufacturers everywhere are switching to MECHANICS Joints and Safety Shields for dependability and safety. Write for information about joint types, sizes, etc.

ROLLER BEARINGS are so tightly sealed-in that dirt and moisture cannot enter.

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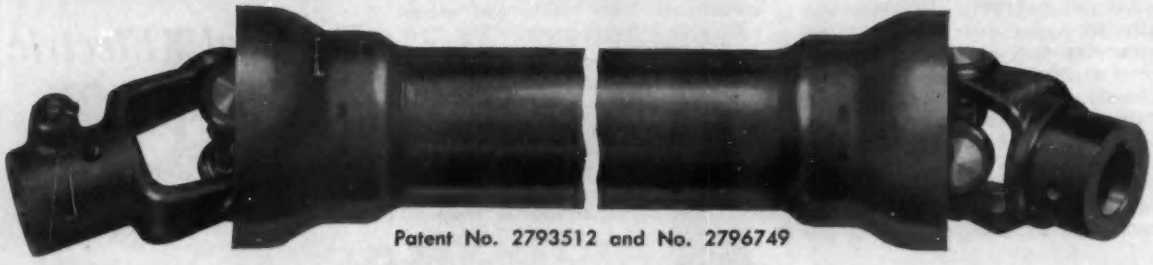
Shield can be removed and serviced by the operator—using only a screwdriver.

MECHANICS
Roller Bearing BW
UNIVERSAL JOINTS
For Tractors • Trucks and Farm Machines



Patent No. 2793512 and No. 2796749

Briefs of SAE PAPERS

Continued from page 116

Safety Aspects of Vehicle-Road Relationships, L. C. LUNDSTROM. Paper No. 66B presented June 1958, 25 p. Study must include motor vehicle transportation system, interstate highways, primary, secondary, and urban systems; to ensure high degree of safety following factors must be considered: geometric features of road, design speeds, surface condition as related to skid resistance, vehicle acceleration characteristics, constant speed conditions, and roadside hazards.

How Will Future Motor Cars Affect Highway Construction? J. B. BIDWELL, R. S. CATALDO. Paper No. 66C presented June 1958, 8 p. Critical appraisal of potential effects of automatic control on transportation system and evaluation of electronic control systems and driver aid devices; car-driven relations; automatic control, besides enhancing convenience, safety and rapidity of personal transportation, can reduce highway construction cost by increasing road capacity; advantages provide strong incentive for rapid development.

Mercedes-Benz Experience with Aluminum Parts in Automotive Engines, E. HUNDT. Paper No. 68B presented June 1958, 7 p. Selection of alloy is determined by task of particular part on vehicle or engine; when part is to be under high stress, light metal will be cast aluminum alloys or, in special cases like diesel, gasoline injection, or racing engines, forgeable aluminum alloys; guiding lines for application of light metal with reference to various parts and engine applications; advantages and disadvantages.

Aluminum Engines-Design for Modern Fabrication, J. M. SMITH, R. M. SMITH. Paper No. 68A presented June 1958, 25 p. Problems encountered in adapting V-type engine, such as is used in Le Sabre and XP-300 experimental cars, to fabrication methods using aluminum alloy parts; design requirements for sand casting; applications in crankcase and cylinder block, cylinder liners and heads, intake manifold, pistons, and bearings; miscellaneous parts.

Design of Hydraulic Power Steering, R. A. PITTMAN, W. A. VAN WICKLIN. Paper No. S107 presented Mar. 1958 (Indiana Sec.), 10 p. Design factors of Ford XR-49 integral power gear as used in Edsel and Lincoln car; main components are manual gear reduction unit, power cylinder, differential, hydraulic control valve, reaction mechanism, and pump assembly.

Engine Cooling, R. H. GARRETT. Paper No. S105 presented Apr. 1958 (British Columbia Sec.), 12 p. It is shown that heat transfer is governed by simple laws and that most cooling problems of diesel engine applications can be solved by means of rational methods; four groups considered: transfer of heat direct to heat sink, to generation of steam, by means of heat exchanger, and through water to steam.

Those Amazing Minicars, D. L. COHOE. Paper No. S97 presented Jan. 1958 (Detroit Sec.), 14 p. Features of representative examples evolved to meet European needs of transportation and defined as vehicle with three wheels, providing complete weather protection for two passengers, and hav-

Continued on page 121

Dual
VISION-AID HEADLAMPS
TUNG-SOL ELECTRIC INC.
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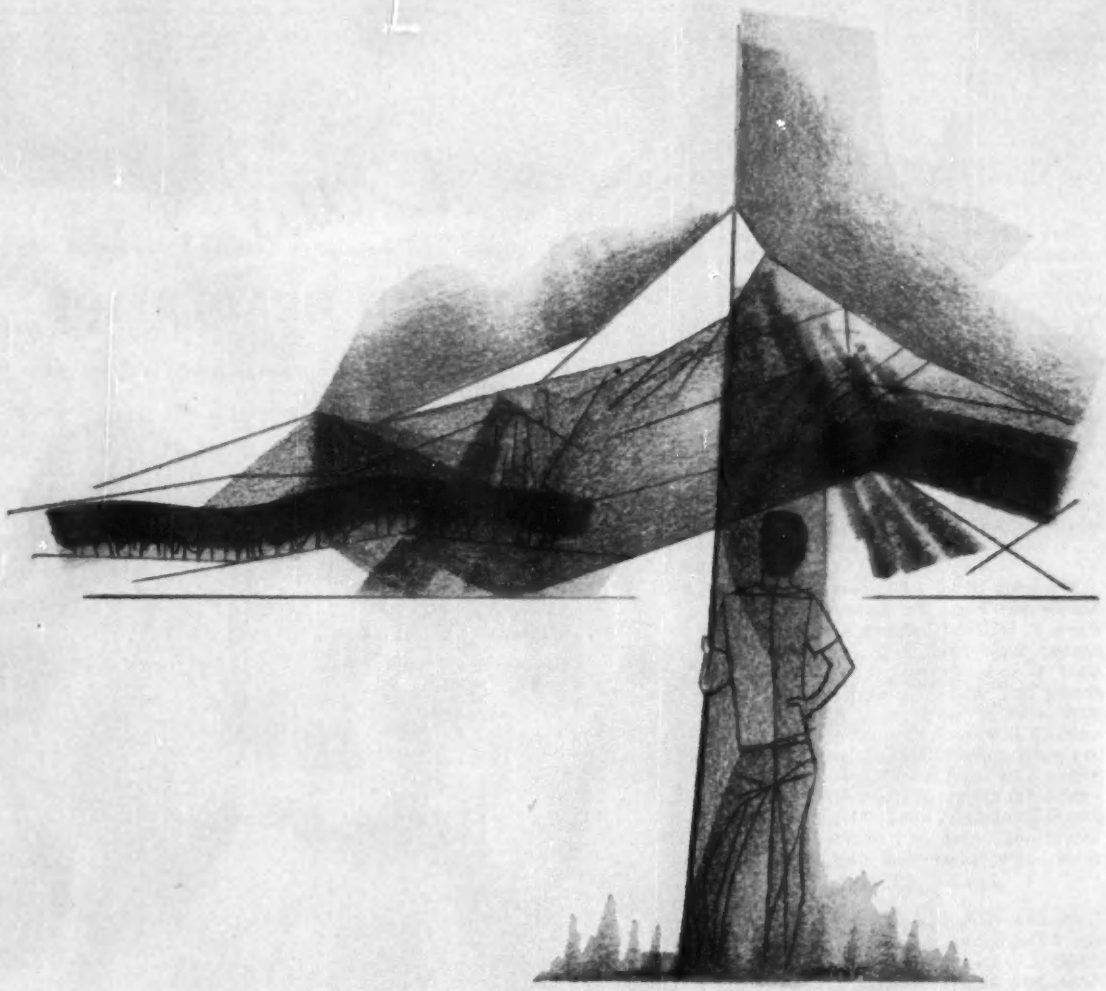


"I FIND THE GREAT THING IN THIS WORLD IS NOT SO MUCH WHERE WE STAND, AS IN WHAT DIRECTION WE ARE MOVING."

OLIVER WENDELL HOLMES

CARTER CARBURETOR
DIVISION OF acf INDUSTRIES, INCORPORATED
ST. LOUIS 7, MISSOURI

Briefs of SAE PAPERS

Continued from page 119

ing max engine displacement of 500 cc; reference is made to overall mini-car market, performance, engine size, type, and location, power train and suspension; body construction; styling; specifications.

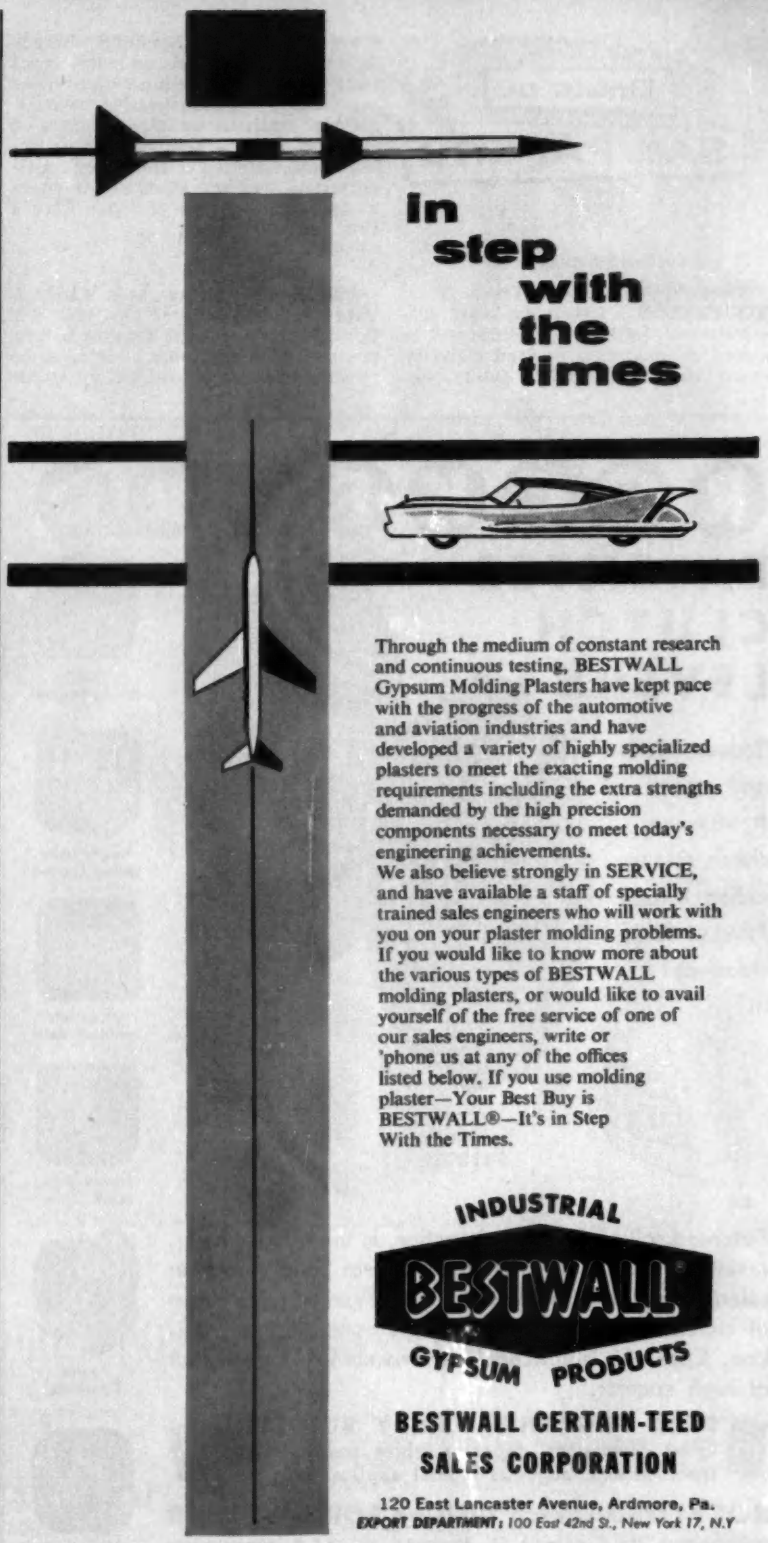
Synchronized 12-Speed Heavy Duty Transmission, E. J. BARTH. Paper No. S68 presented Feb. 1958, 14 p. Review of Dana Corp.'s transmissions and targets for new design for heavy duty trucks, based on previous experience, progress in design and field testing; completed transmission, Model 8125, with aluminum case, bell and shifter housing weighs 600 lb, incorporates synchronized and power shifts, gear hopper guards, and has 12 speeds with average of 1.26 between ratios; overall spread 13.1 to 1; method of control.

Are Shock Absorbers Here to Stay? R. C. CLINE. Paper No. S106 presented May 1958 (Atlanta Sec.), 6 p. Special reference to absorber, built by Gabriel Co., Cleveland, Ohio; three distinct phases of valve action operating at successively higher piston speeds are: low speed orifice, blowoff valve and high speed orifice; future trends and role that shock absorbers play in passenger comfort.

Fundamentals of Piston Ring Function and Design as Applied to Industrial Engines, J. O. LUTZ. Paper No. S94 presented Apr. 1958 (New England Sec.), 11 p. Basic compression ring gap designs; types of inclined face piston rings; use of rings made from either statically or centrifugally cast alloyed iron, having higher strength than piston ring iron; oil control ring; types of coatings employed; ring and groove wear; cylinder wear and finish.

Opportunities for New Development of Heavy Duty Brakes, Tires and Wheels, H. A. DOZIER, R. W. KUPP. Paper No. 69A presented Aug. 1958, 16 p. Shortcomings found by truck operator and presentation of ideas as to what may be done to correct them; opposing shoe type of brake, use of exhaust brake, means of brake balance, and problem of brake lag time dealt with; it is suggested that SAE step up standard brake lag test for all production vehicles; use of steel cords and tread design employing Micro-Sipe pattern is proposed.

Continued on page 122



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SALT LAKE CITY, UTAH
SUMMIT, N.J.
TACOMA, WASH.
WILMINGTON, DEL.

Briefs of SAE PAPERS

Continued from page 121

Tires for Tomorrow's Truck, T. A. ROBERTSON. Paper No. 69B presented Aug. 1958, 13 p. Design will be aimed at maximum payload capacity, speed and load carrying ability, improved safety and handling characteristics with emphasis on riding comfort; these trends require high speed heat resistant truck tire and development of synthetic tread with improved abrasion and cracking resistance; importance of steelcord tire to bus transportation; rim and wheel development and tread design; use of tubeless truck tire.

Pity the Poor Brakes, J. V. BASSET. Paper No. 69C presented Aug. 1958, 6 p. Consideration of brake balance factors pointing out importance of using same friction value lining on all units; use of high friction brake blocks because their use reduces air requirements is stressed; some unit of standard friction value must be decided upon by transportation industry if any semblance of balance is to be achieved, particularly on interchange units.

Problems of Estimating Construction in Changing Economy, W. R. STEVENS. Paper No. 70A presented Aug. 1958, 3 p. Estimate of probable cost is prepared by determining cost of materials, construction equipment, labor, overhead, and profit; it is necessary to include cost for all equipment used, cost of transporting it to and from project; methods of charging equipment costs to project which should include fuel, lubrication, maintenance, repairs, etc.; factors to consider in estimating labor costs.

Applying Today's Ripper to Job, R. D. EVANS. Paper No. 70B presented Aug. 1958, 14 p. Problem of ripping is to provide fragmentation or size reduction of mass so that resulting material can be rehandled or loaded; basic equipment design and features required taking into account function of clevis, types of shanks, and points; table listing ripable and nonripable materials; transportation methods, recommended procedure for ripping rock; cost and performance comparisons.

Rubber Tires for Heavy Construction Equipment, C. W. MOSS. Paper No. 70C presented Aug. 1958, 5 p. Special tires within group of low pressure tires differ only in tread design, such as rock and traction type, and overall pattern types, used on trailing wheels; example of heat failures and effect of heat increase on tire life demonstrate need of development of more specialized tires for each individual job; wide base tires to improve flotation and traction; tubeless off-road tires.

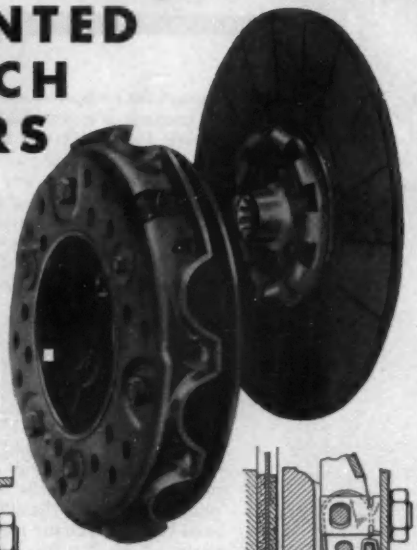
Hydrotarder Applications on Industrial and Heavy Duty Off Highway Equipment, A. H. HETZEL. Paper No. 70D presented Aug. 1958, 22 p. Hydrotarder is used as speed governor for heavily loaded vehicles traveling long and/or steep downgrades in all types of hauling operations to provide retarding effort, and to relieve wheel friction brakes; action is obtained solely by hydro-kinetic action; principles of Hydrotarder; schematics of circulation system; alignment chart of performance.

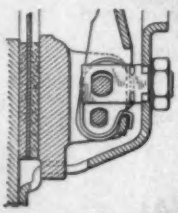
Continued on page 124

ROCKFORD

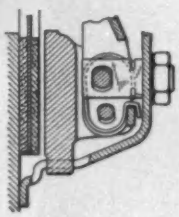
PATENTED CLUTCH LEVERS

Reduce friction and wear • Improve clutch release action • and Prevent lever throw-out





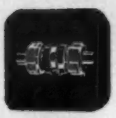
Patent No. 2818952



Patented rolling fulcrum pin action, in the release lever, results in much less friction and wear, and smoother release operation in this clutch than in some other types of clutches. Pin automatically returns to original position. Carefully balanced levers avoid lever throw-out at high speeds.

Small Spring Loaded

Heavy Duty Spring Loaded



Oil or Dry Multiple Disc

Heavy Duty Over Center

Power Take-Offs

Speed Reducers

SEND FOR THIS HANDY BULLETIN
Gives dimensions, capacity tables and complete specifications. Suggests typical applications.

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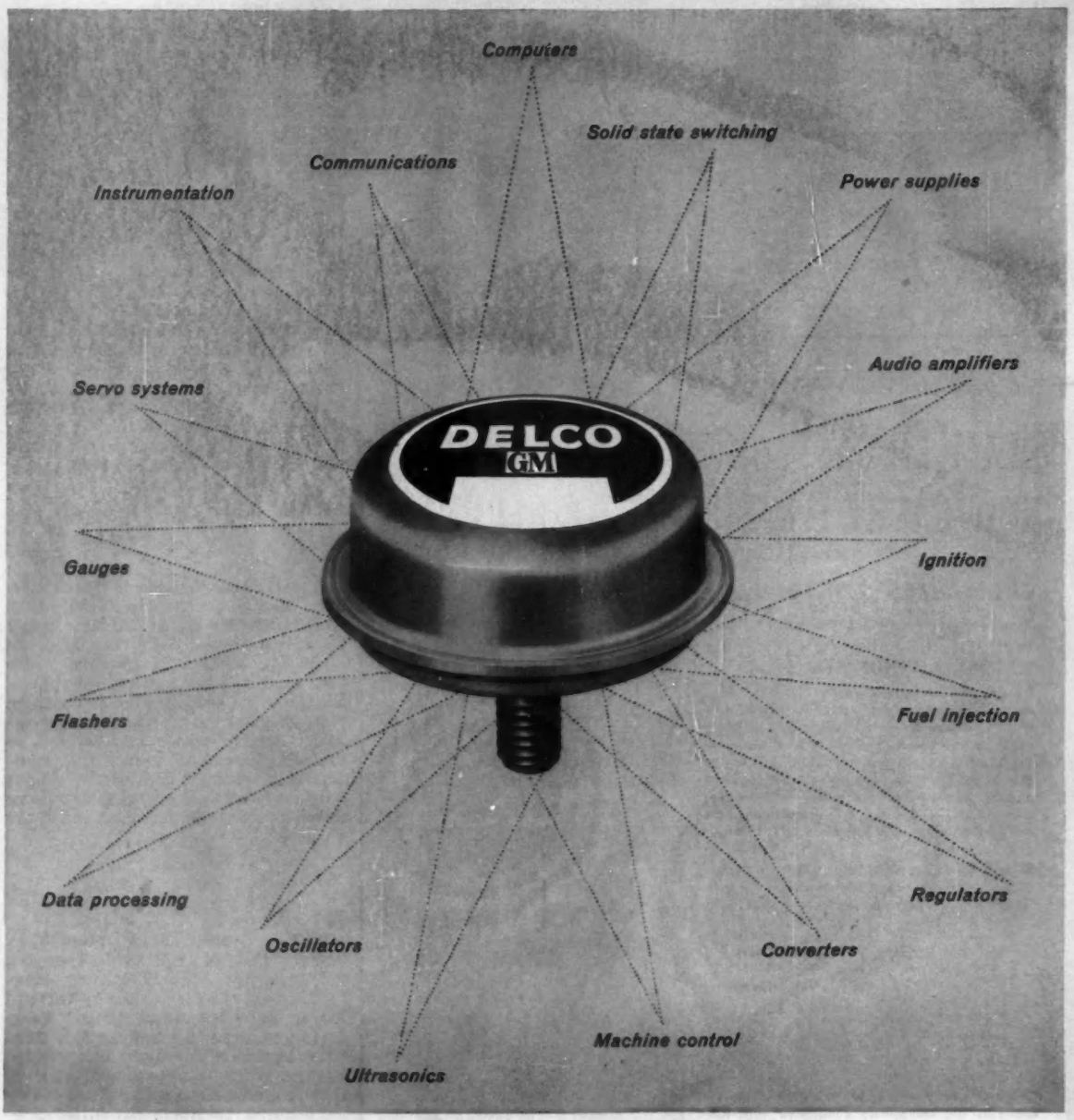
Export Sales Borg-Warner International — 36 So. Wabash, Chicago 3, Ill.

CLUTCHES



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Briefs of SAE PAPERS

Continued from page 122

Wagner 4-Wheel Drive Tractor, J. B. LONG, E. A. WAGNER. Paper No. T36 presented Sept. 1958 (Milwaukee, Wis.), 3 p. Data on farm tractors, manufactured by Wagner Tractor Co., featuring Pow-R-Flex coupling, 4-wheel drive, and 4-wheel powered steering; units are powered by Cummins Diesel Engine ranging from 110, 125, 160 and 300 bhp respectively; planetary drive system; tractor performs most effectively with 10 or 12 ply tires on all wheels; diamond treads are recommended.

Knock Knock—Spark Knock, Wild Ping or Rumble? R. H. PERRY, JR., H. V. LOWTHER. Paper No. 61E presented June 1958, 12 p. Progress made in study by Research Dept. of Socony Mobil Oil Co., to minimize these occurrences; very exact tailoring of fuels, lubricants, additives and engines appears necessary to prevent engine noise, abnormal combustion and/or spark plug misfiring.

Knock, Rumble and Ping, H. F. HOSTETLER, W. R. TUURI. Paper No. 61F presented June 1958, 7 p. Standard Oil Co., Ohio, road test program involved 64 fuel combinations following statistical design to study deposit effects on base stocks and additives; laboratory tests to obtain fuel-additive information and to study engine operating variables; results indicate that wild ping is associated with octane number and rumble to surface ignition; fuels can be designed to provide minimum rumble through proper selection and blending.

Investigating Rumble in Single-Cylinder Engines, J. A. ROBISON, M. D. BEHRENS, R. G. MOSHER. Paper No. 61H presented June 1958, 12 p. In approach, undertaken by Ford Motor Co., to define phenomenon, emphasis is placed on studying causes of high rates of pressure rise; in flame propagation study, rumble is measured by multiple ionization gaps; it is concluded that rumble is caused by deposit ignition in end gas region from one or more sources, and piston deposits are major cause.

If You Squeeze Them, Must They Scream? W. M. WIESE. Paper No. 61J presented June 1958, 19 p. Statistical test method applied by General Motor Research Staff, to determine octane requirements and surface ignition tendency of high compression engines when using various types of fuel to accumulate combustion chamber deposits; results indicate that gasoline tail end volatility, aromatic content, and additive treatment have measurable effects on both factors.

MATERIALS

"Delrin" Acetal Resin, New Engineering Material, H. H. GOODMAN, J. D. YOUNG. Paper No. 60A presented June 1958, 18 p. Plastic polymer of formaldehyde, developed by Du Pont de Nemours & Co., differs from previous resins because of its very long chains and excellent thermal stability; it will be available commercially in 1959; physical properties and processi-

Continued on page 128

BEAM LP-GAS CONVERSION SYSTEMS NOW CARRY U.L. LISTING BY REPORT

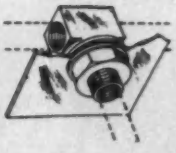
Customized Conversions

Specifically designed for the vehicle being converted.

TO THE LAST NUT AND BOLT

These assemblies are complete: Vaporizer-regulator, solenoid valve, fuel filter and vacuum switch are mounted on a plate precision-engineered and drilled for the specific truck being converted. All fittings are included, hoses are pre-cut to required lengths and schematic drawings show exact location of fuel cylinder. ICC cylinder brackets are included. A Bill of Materials lists all part numbers.

Installation instructions are so easy to follow that the average mechanic can do the job in approximately two hours without special tools.

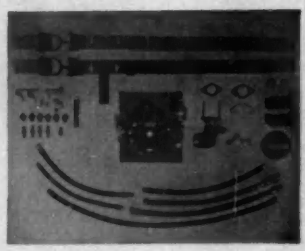


And each unit is equipped with BEAM'S New Bulkhead fitting

See BF-23

Chafing and wearing of the high pressure fuel line are completely eliminated with the hydrostatic relief valve installed outside the engine compartment.

Complete copies of Underwriters' Laboratories "Listing by Report" showing actual photographs of installations with instructions, diagrams, etc. are available from Beam Products Mfg. Co. or from Underwriters' Laboratories covering the following trucks — Yale Models KG-51-30 through KG-51-100 with suffix letters A, AT, T, R, P and S; Hyster Models UE 30, YE-40, HE-50, UE-30T, YE-40T and HE-50T; Clark Carloader Models 3024, 4024, 5024, and Towmotor Models 420-460-480-480P-500 and 500P.



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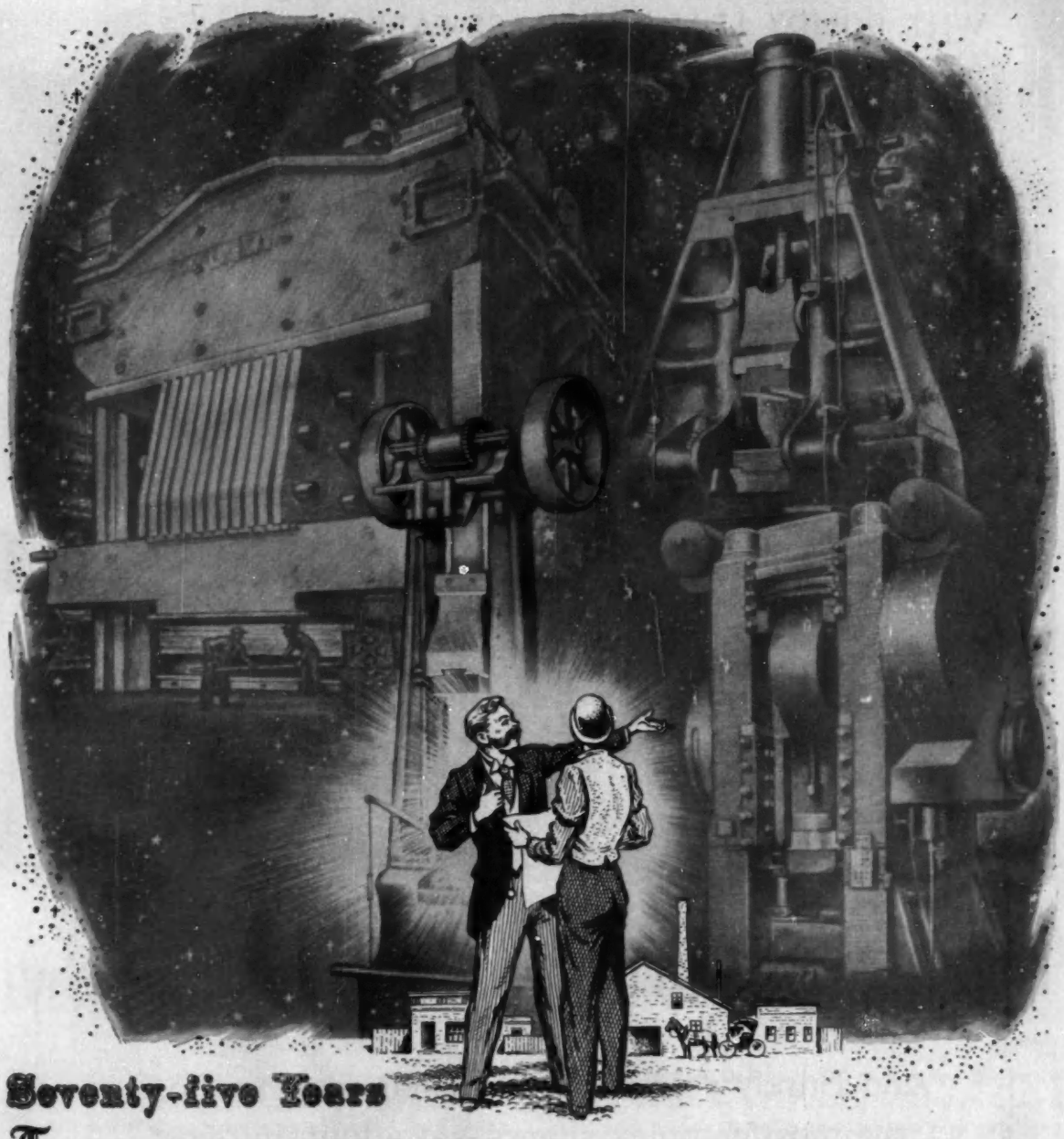

Seventy-five Years

THERE WAS a growing surplus in the United States Treasury—the Polygamy Act was passed—letter postage was reduced from three cents to two cents—the Brooklyn Bridge was opened—standard time was adopted—in 1883, when two young men, just graduated from Worcester Polytechnic Institute, established the business bearing their names—WYMAN-GORDON. The total capital was $27,000.

Integrity, initiative, ambition and ability were theirs. Endowed with these qualities and privileged to operate under that unique American system of free, private, competitive enterprise the Company prospered and grew.

On this our 75th anniversary, we salute the spirit of our founders and we pledge our every effort to help preserve, against the steady erosion of the last quarter century, that system which has made our nation what it is today and which has enabled us to build the greatest industrial production in the world, resulting in the highest standards for all segments of our people.

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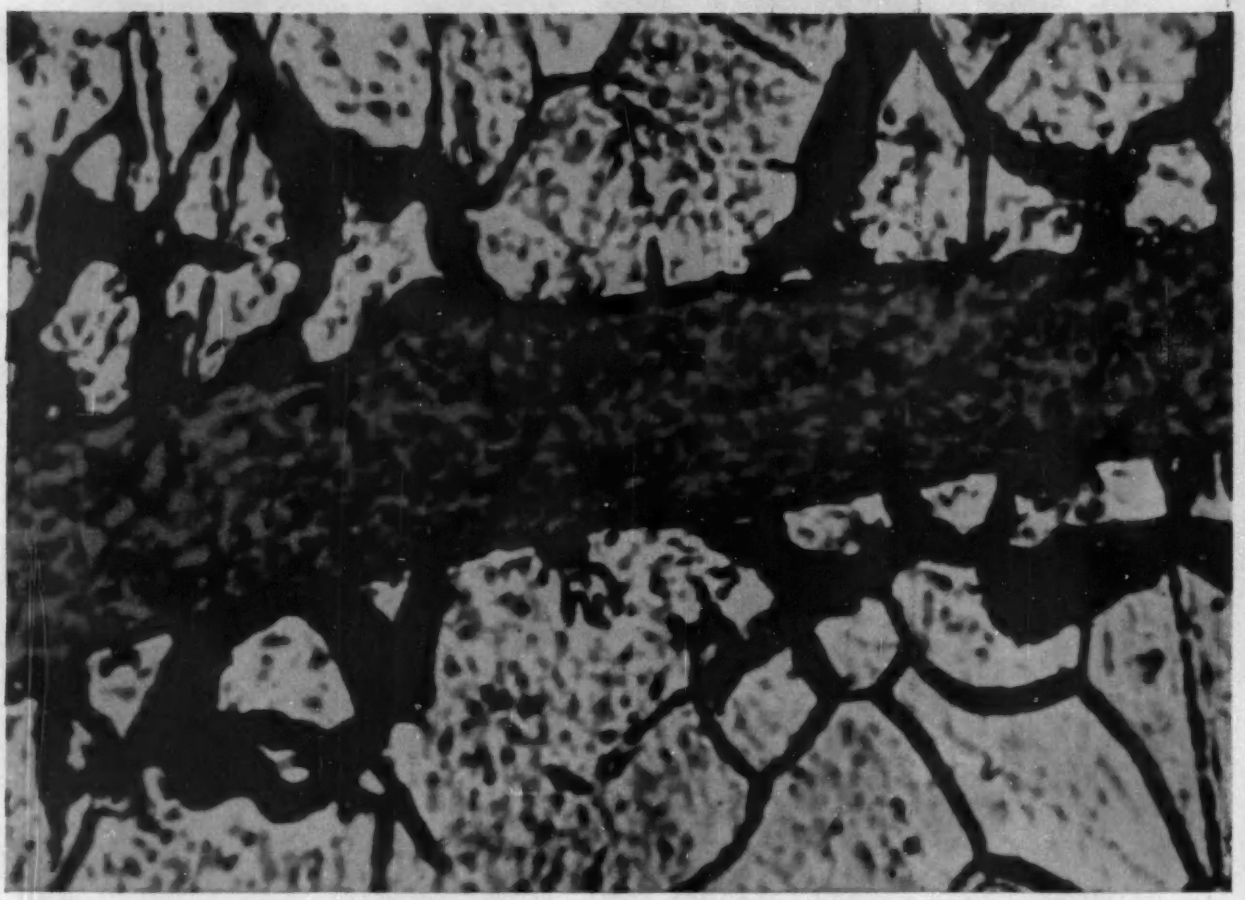
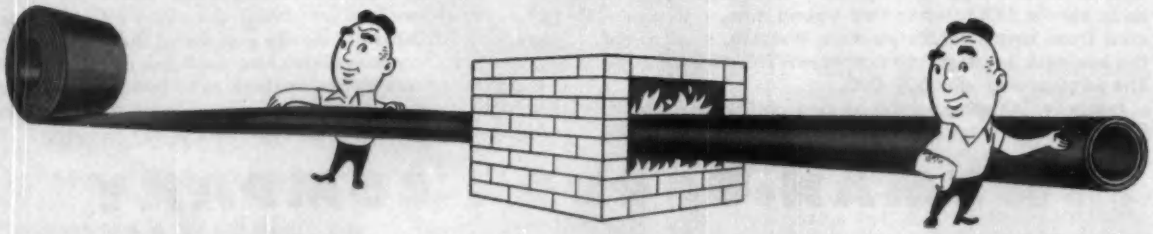
WHY BUNDY LEADS IN MASS-FABRICATION:



COPPER BRAZING...Another reason why

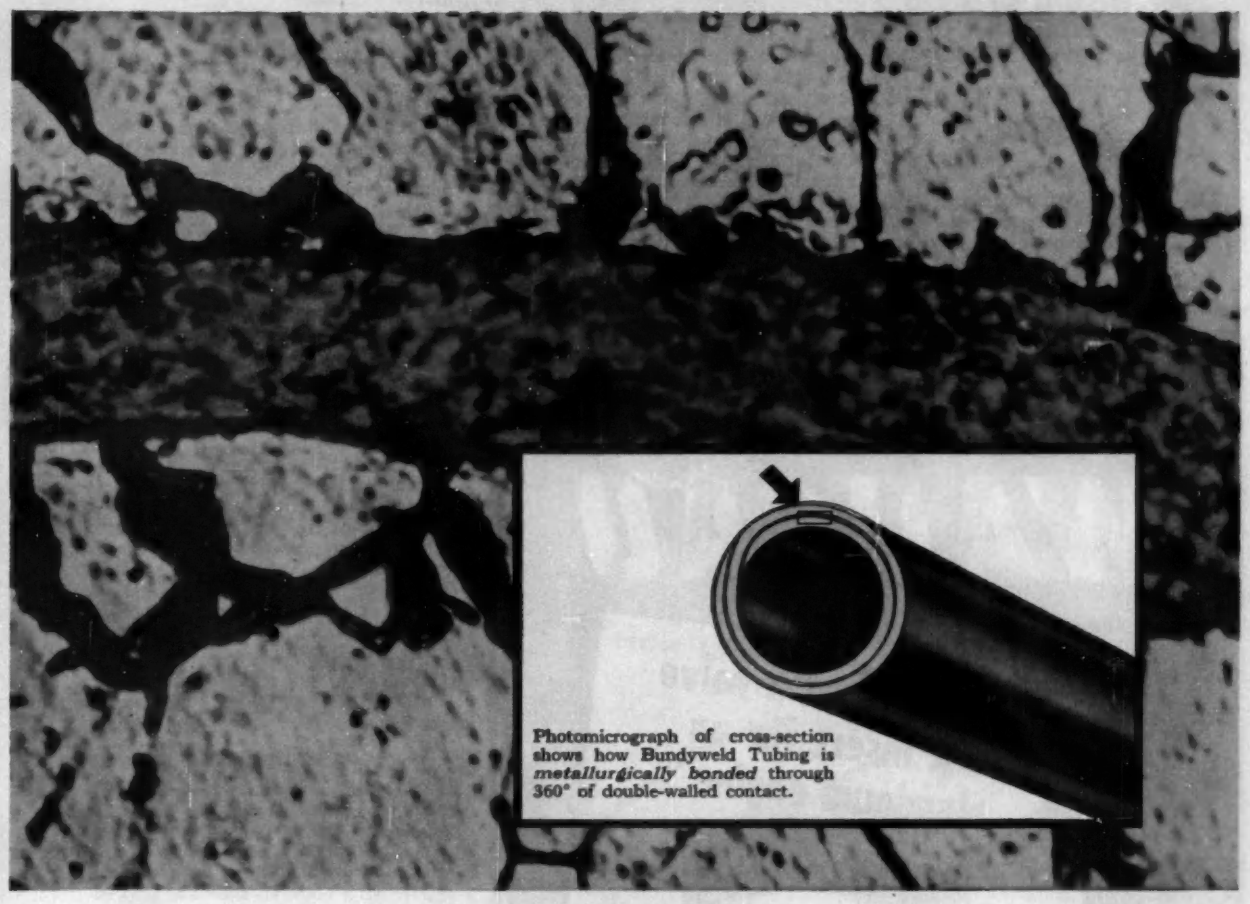
And Bundyweld can be mass-fabricated even in the most complex shapes—at a low unit-cost which results from three Bundy advantages:



Bundyweld starts as a single strip of copper-coated steel. Then it's continuously rolled twice around laterally . . .

into a tube of uniform thickness, and passed through a furnace where copper coating fuses with basic steel.

Result: Bundyweld Tubing—double-walled, beadless, metallurgically bonded through 360° of wall contact.


Photomicrograph of cross-section shows how Bundyweld Tubing is *metallurgically bonded* through 360° of double-walled contact.

Bundyweld prevents hydraulic leakage

This tubing was passed through a furnace where its copper coating *fused* permanently with base steel. It's just one of three reasons why Bundy• leads in the modern art of mass-fabrication.

Bundyweld Tubing• is copper-brazed to stay *leak-proof by test*. It stands up through brutal shock and punishing vibration . . . still handles high-pressure hydraulics with perfect safety. No wonder Bundyweld is used on 95% of today's cars, in an average of 20 applications each.

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Briefs of SAE PAPERS

Continued from page 124

bility; possible automotive applications; advantages offered over metals in ease of fabrication by injection molding, good frictional properties, abrasion and corrosion resistance.

Hypereutectic Aluminum-Silicon Alloys, R. M. SMITH. Paper No. 65A presented June 1958, 8 p. Program of reevaluation and investigations of new techniques, undertaken by Aluminum Co. of America, properties of aluminum alloy containing 20% Si, 2% Cu, 1% Mg and 0.5% Mn; corrosion; applications include pistons, cylinders, rocker arms, and brake drums; products include forgings, die castings, permanent and semipermanent mold and sand castings.

Sprayed Metallic Coatings for Automotive Aluminum Castings, H. S. INGHAM. Paper No. 65B presented June 1958, 9 p. Method of bonding with molybdenum provides molecular bond between particles of sprayed molybdenum and aluminum surface, permitting use of pure molybdenum as hard facing material, with coatings as thin as desired; hard facing on cylinders and cylinder liners; other automotive applications; protection against corrosion of aluminum castings used on highway truck trailers.

Latest Developments in Impact Extruded Aluminum Alloys, R. A. QUADT. Paper No. 65D presented June 1958, 11 p. Trend toward production of longer, larger, and more complex impacts in stronger, heat treatable alloys and in compacted sintered aluminum powder for higher temperatures; illustrated examples of large complex parts produced at Hunter, Douglas Aluminum Division, having multiple OD's and ID's nonsymmetrical cross sections; application of extrusion in automobiles and aircraft, rocket, missiles, etc.

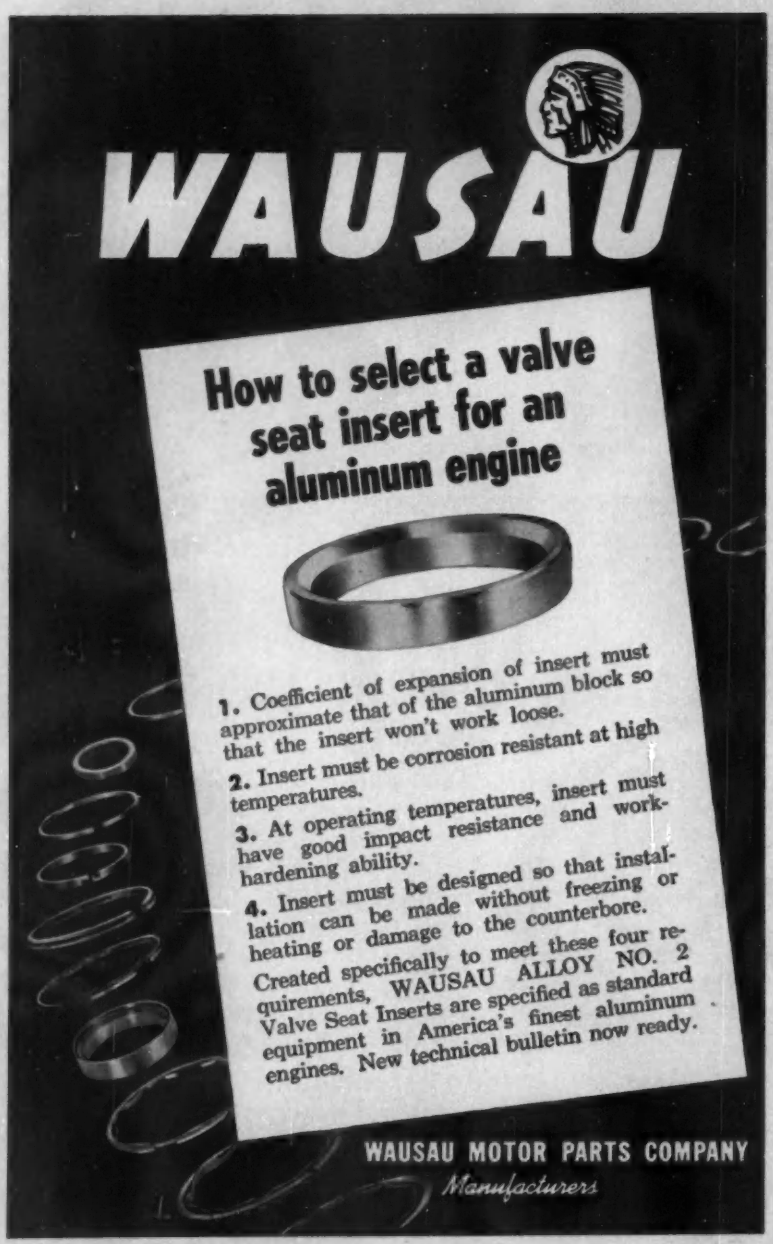
MISCELLANEOUS

Symbiotic Interaction Between Science and Engineering, G. GROETZINGER. Paper No. 54A presented June 8–13, 1958. Definition of task of science and nature of engineering; relationship between scientist and engineer; interplay of engineering and science is demonstrated by various examples showing how scientific discoveries provided basis for technical development; concepts of physical theories and nuclear physics; developments related to electrical engineering.

PRODUCTION

Application of Radial Draw Forming Process to Automotive Components, L. A. Allison. Paper No. 65C presented June 1958, 6. p. In this process actual deformation of metal takes place "line-at-a-time" instead of subjecting entire metal sheet to forming pressure at one instant; there are three major components used: rotating die holder, hydraulic stretch cylinder, and compression wipe shoe; draw forming of bumpers, tops, body frame members, molding grills and trim pieces; advantages.

These digests are provided by Engineering Index, which abstracts and classifies material from SAE and 1200 other technical magazines, society transactions, government bulletins, research reports, and the like, throughout the world.


WAUSAU
How to select a valve seat insert for an aluminum engine
1. Coefficient of expansion of insert must approximate that of the aluminum block so that the insert won't work loose.
2. Insert must be corrosion resistant at high temperatures.
3. At operating temperatures, insert must have good impact resistance and work-hardening ability.
4. Insert must be designed so that installation can be made without freezing or heating or damage to the counterbore.
Created specifically to meet these four requirements, WAUSAU ALLOY NO. 2 Valve Seat Inserts are specified as standard equipment in America's finest aluminum engines. New technical bulletin now ready.
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Manufacturers
2600 Eau Claire St., Schofield, Wis. • Detroit Office: 1302 Cadillac Tower, Detroit, Mich.

Vibration Bedevils Helicopter Designer

Based on talk by

B. W. SZNYCER
Omega Aircraft Corp.

(Presented before SAE Syracuse Section)

VIBRATIONS are the bug-a-boo of the helicopter designer. There are the vibrations of the rotor in the plane of rotation and in the plane of flapping in natural frequencies in first, second, and third modes. In addition, there are the tail rotor vibrations, with their own modes and frequencies. Then there are the engine frequencies of all proper orders.

Add to this the blade passing over the fuselage, producing impulses and affecting the vibration characteristics caused by action of the rotor wake on the exposed fuselage surfaces.

Outside of bending frequencies of the blades and torsional frequencies of the engines, the spring constants of the main rotor shaft and supporting structures have to be considered and, of course, the fuselage has to be designed so as not to be tuned in to any of the above mentioned frequencies in the lower range.

To call it a nightmare would be inappropriate inasmuch as the solution to these problems seldom comes during sleep. They have to be carefully considered, however, both on paper and during flight testing.

In the Omega design — a utility flying crane — the added attraction was the rotor operating the tip speed corresponding to Mach 0.7. This, in itself, can contribute to violent vibrations due to the compressibility effect on the advancing side of the rotor in high-speed forward flight.

Porous Walls Solve Transonic Tunnel Troubles

Based on paper by

J. T. KENNEY,
P. V. H. SERRELL,
and
Y. N. YU
Sandberg-Serrell Corp.

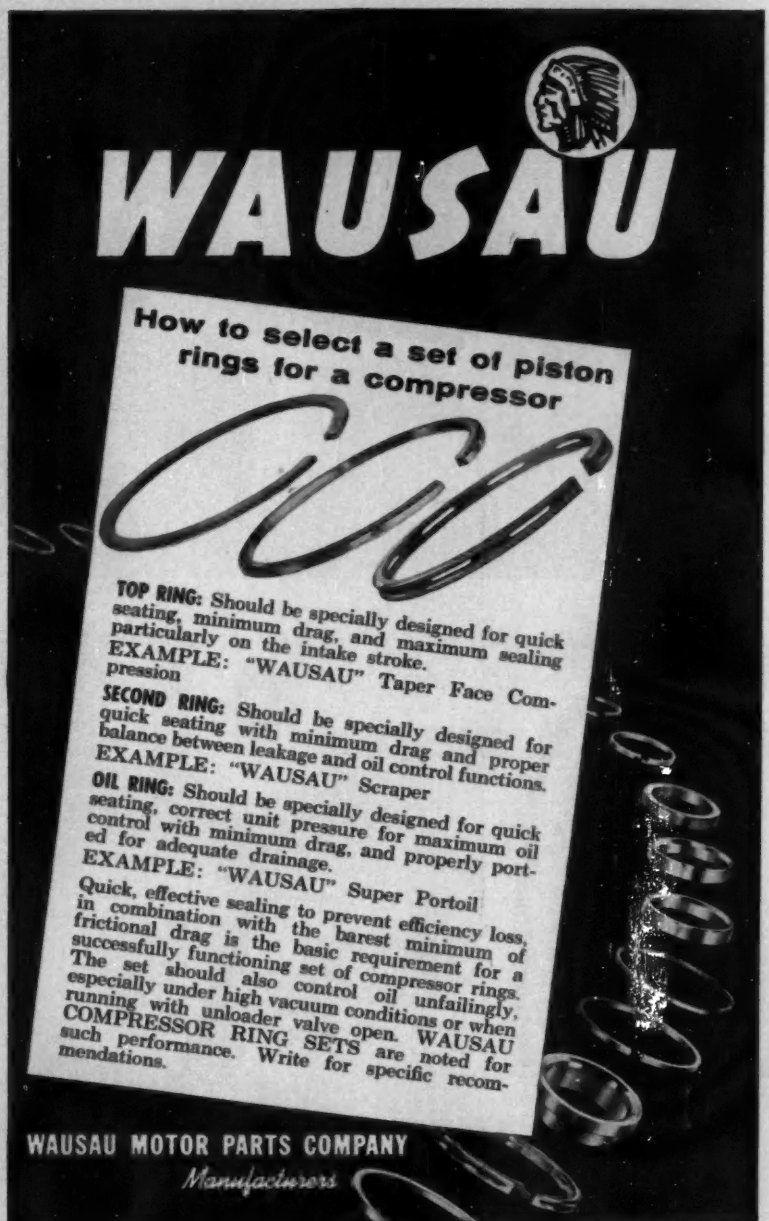
POROUS test section walls have solved what was once a troublesome problem with transonic wind tunnels.

The problem results from this fact: In free flight the air in the region of the aircraft is influenced only by the aircraft. In the wind tunnel it is also influenced by the nearby tunnel walls.

Good corrections can be made up to about Mach 0.5. From there on, this influence increases with increasing Mach number until it is overpowering between about Mach 0.9 and 1.2. Any attempt to take a model through Mach 1 in a solid-walled, fixed-geometry test section results in this situation: Proceeding from the test section entrance downstream, we find a nice region of uniform high subsonic flow up to the nose of the model. From there the velocity increases up to Mach 1 at the maximum cross-section of the model and support system. Beyond the maximum section, the flow goes supersonic and almost immediately drops to subsonic through a standing shock wave normal to the flow.

Under these circumstances the tunnel is said to be "choked" due to the "blockage" of the model. Furthermore,

continued on page 131


WAUSAU
How to select a set of piston rings for a compressor
TOP RING: Should be specially designed for quick seating, minimum drag, and maximum sealing particularly on the intake stroke.
EXAMPLE: "WAUSAU" Taper Face Compression
SECOND RING: Should be specially designed for quick seating with minimum drag and proper balance between leakage and oil control functions.
EXAMPLE: "WAUSAU" Scraper
OIL RING: Should be specially designed for quick seating, correct unit pressure for maximum oil control with minimum drag, and properly ported for adequate drainage.
EXAMPLE: "WAUSAU" Super Portoil
Quick, effective sealing to prevent efficiency loss, in combination with the barest minimum of frictional drag is the basic requirement for a successfully functioning set of compressor rings. The set should also control oil unfailingly, especially under high vacuum conditions or when running with unloader valve open. WAUSAU COMPRESSOR RING SETS are noted for such performance. Write for specific recommendations.
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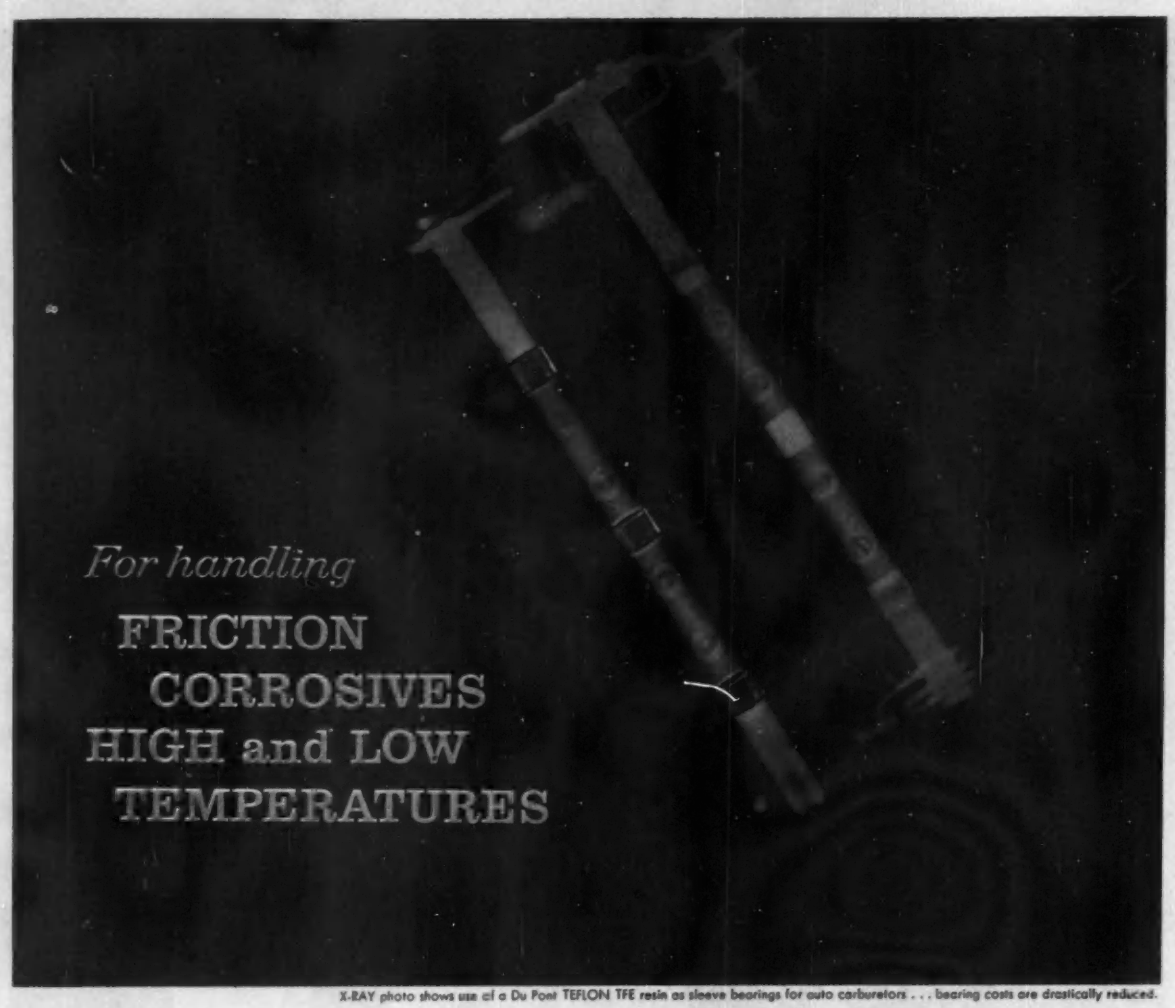

X-RAY photo shows use of a Du Pont TEFLON TFE resin as sleeve bearings for auto carburetors . . . bearing costs are drastically reduced.

Here's why bearings of TFE-fluorocarbon resins may be your solution

Bearings of TFE-fluorocarbon resins are "self-lubricating". Even the best lubricants used on metal rarely provide a coefficient of friction as low as 0.04, which is readily attained with TFE resins at low velocities. Moreover, TFE resins are among the most chemically inert materials known to science. They are rated for continuous use at temperatures from —450°F. to 500°F.

THAT'S WHY: You can use *dry bearings* of TFE resins where lubrication is difficult or even impossible. As in the carburetor pictured above, they perform unharmed in contact with gasoline, oil, grease, and automotive chemicals. These bearings eliminate slip-stick motion and remain unchanged in cold that turns alcohol to slush.

In use, the bearings coat revolving shafts with a molecular film of the TFE resin. Thus, any friction is that of the resin against itself. Bearings of TFE resins can be tailored for high loads, high velocities or high wear-resistance by the use of reinforced constructions.

Discover how you can improve automotive products and production with bearings of Du Pont TFE-fluorocarbon resins. For product and design information see your local supplier. Look for him under "Plastics—Du Pont" in the Yellow Pages or write to: **E. I. du Pont de Nemours & Co. (Inc.), Room SA2524, Nemours Building, Wilmington 98, Delaware.**

In Canada: Du Pont Company of Canada (1956) Limited, P.O. Box 660, Montreal, Quebec.

• A heavy duty TFE resin construction replaced a super-alloy in rod-ends of aircraft controls. Lined sockets withstand operating loads as high as 60,000 psi without lubrication. Break-away and running friction are less than half that of a greased bearing.

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Applied Research in Radome Development, Antenna Development, Infrared, and Acoustics.

Please write to: Mr. G.K. Stevenson, Engineering Personnel, North American Aviation, Los Angeles 45, California.

THE LOS ANGELES DIVISION OF
NORTH AMERICAN AVIATION, INC.

continued from page 129

even when a Laval nozzle is used to reach low supersonic speeds, the shock wave from the nose of the model reflects from the wall against the tail of the model.

The solution to these problems was an interesting development, and due to security reasons is not much known outside aeronautical circles. The break-through came when someone considered the fact that compression shock waves reflect off solid walls as a compression shock wave, and off a free jet boundary as a rarefaction wave. The thought was to make the test section wall of longitudinal slats so that the compression and rarefaction shocks would cancel before they got back to the model. Also, it was hoped that there would be well-defined sonic throat in the test section at the maximum area of the model.

The first hope, that of shock cancellation, was only partially realized. On the other hand, the hope of de-blocking was realized. The amazing beauty of this type of test section is that it will allow the flow to go smoothly through Mach 1, and to reasonable supersonic speeds without the need of changing physical geometry.

Subsequent tests showed that a porous test section wall was superior to a slatted one, and is the standard technique today. The largest transonic tunnel, having a 16 × 16 ft test section, is located at the Arnold Engineering Development Center, Tullahoma, Tenn.

To Order Paper No. 84C . . . on which this article is based, see p. 6.

Centrifugal Filter Of New Design Suggested

Excerpt from Student Award Paper by

H. HARRY MUEGGENBURG

and

J. FAUSTINO CUTTI

Students at California State Polytechnic College

(This paper received the 1958 Mac Short Memorial Award, presented by the SAE Southern California Section)

MANY efficient centrifugal filters are on the market, but they are all rotated by an outside power source, such as an electric motor.

Since most industrial fluids to be filtered are under pressure, why not

continued on page 133

work in the fields of the future at NAA

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Immediate opening for top-level man, qualified to work up to supervisory status, to work on the most advanced weapon systems as the B-70 and the F-108, and the X-15—first manned space ship.

He should have a background in EE, ME, or Physics, with an accent on several years experience in acoustics.

He'll calculate and measure sound levels for consulting on procedures to insure crew comfort and efficiency; and work out sound environment problems on equipment of particular airframes and structural fatigue problems resulting from high acoustical levels.

There are also challenging opportunities for less experienced acoustical engineers.

Write to: Mr. G. K. Stevenson, Engineering Personnel, North American Aviation, Inc., Los Angeles 45, California.

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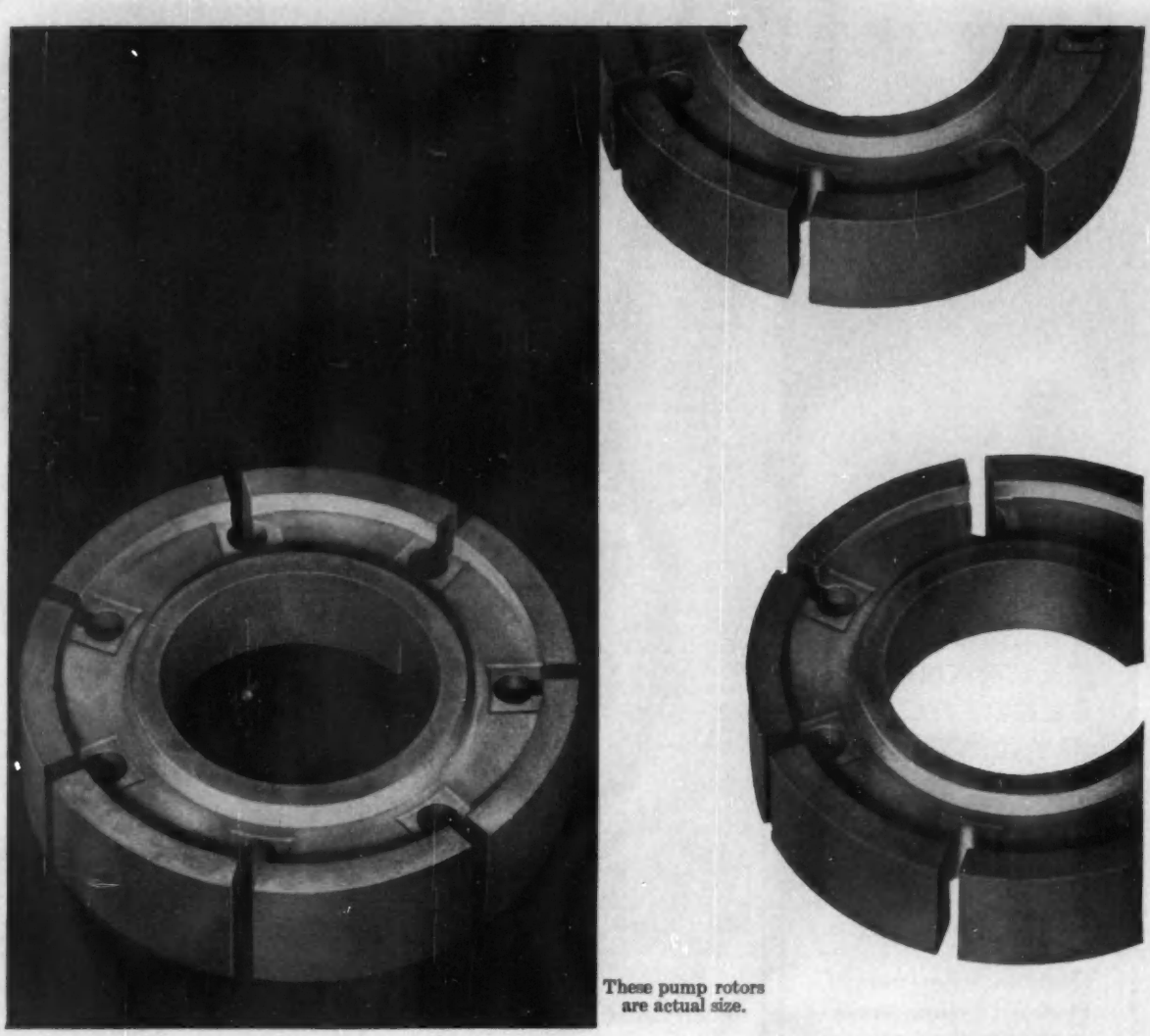


These pump rotors are actual size.

Just how *strong* are sintered metal parts?

Sintered metal parts by Moraine Products prove their strength and stamina every day on a wide variety of jobs. Take the automatic transmission pump rotors that are shown above. Millions of them perform efficiently and dependably *billions* of times during the life of the transmissions in which they are used. Rugged long-lasting sintered metal parts by Moraine Products are the modern economical answer for an ever-increasing number of applications.

Moraine Products also produces: Moraine Power Brakes • Delco hydraulic brake fluids, brake assemblies, master cylinders, wheel cylinders, and parts • Moraine friction materials • Moraine-400 and M-100 automotive engine bearings • self-lubricating bearings and porous metal filters • rolled bronze and bi-metal bushings.

Moraine Products
Division of General Motors, Dayton, Ohio

continued from page 131

make use of this pressure to rotate the unit?

To make a body rotate with a constant angular velocity, a constant torque is required. To produce a torque, a force, as well as a lever arm, is required. Since pressure is at the designer's disposal, it will be possible to convert this into the force. The lever arm can be acquired by applying the force as far away from the center of rotation as the design permits.

Fig. 1 shows a sectional drawing of the rotor with cap, which rotates about the spindle. Fluid enters the rotor through holes located in the lower half of the hollow spindle. The fluid fills the rotor and then escapes under pressure through the nozzles. The reaction of these nozzles spins the rotor. The greater the pressure of the fluid, the greater the reaction of the nozzles and the faster the rotor will turn.

The reason for locating the nozzles at the top of the container is obvious. The contaminant as it is thrown against the wall of the rotor will eventually settle to the bottom, thus leaving the upper part free of contaminant. Since the jets provide the only oil outlet from the rotor, the fluid leaving the nozzles has been subjected to the centrifugal action, and has, therefore, been filtered.

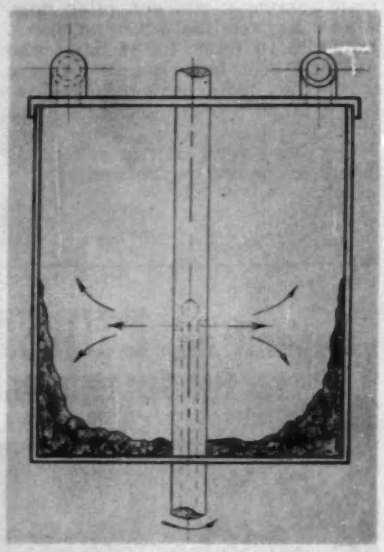
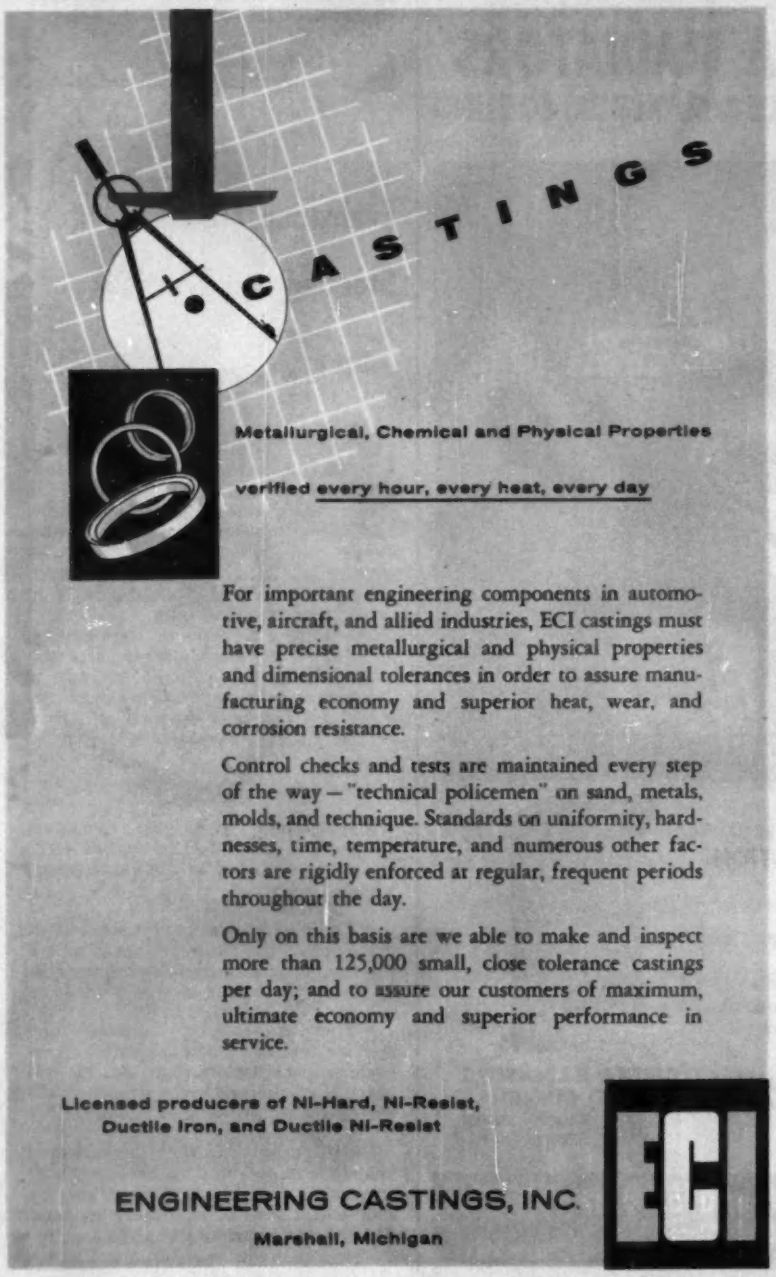


Fig. 1 — Sectional view of centrifugal filter showing rotor spinning on shaft. Fluid enters rotor through holes in shaft. Contaminant is thrown against rotor wall and settles to bottom.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Diesel Users Baffled By Fuel Specifications

Based on paper by

GILBERT K. BROWER
and
WILLIAM LENZI

International Harvester Co.

REALISTIC commercial diesel fuel specifications are sorely needed. And they can be developed if engine builders will reduce the number of divergent fuel requirements and if the petroleum industry will curtail the present permissible practice of excessive dual branding.

At the present time, 41 diesel engine builders have 39 differing fuel specifications. And as for dual branding, 70% of Grade 1-D diesel fuels may be classified as Grade 2-D, and 100% of the No. 1 burner fuel oils may be designated as No. 2 fuels. Moreover, instead of tabulating diesel fuels by ASTM grades, as in the past, they are now listed under so-called classes of service for which the fuels are recommended by the petroleum manufactur-

continued on following page

continued from page 133

ers, which are meaningless to the consumer.

Because of dual branding, the ultimate consumer can, and often does, receive a type of fuel which he doesn't want. Many users, for example, who order 2-D fuels now receive a 1-D type which costs more and which may result in power losses or decreased economy.

The objective of arriving at realistic specifications can be achieved by:

1. Establishing a 550 F minimum 90% distillation limit for the 2-D grade fuel and a 550 F maximum for the 1-D fuel.

2. Incorporating a maximum kinematic viscosity limit for the 1-D fuel; perhaps 2.5 centistrokes at 100 F is in order.

3. Increasing the minimum viscosity limit for the 2-D fuels from 1.8 to 2.0 centistrokes at 100 F.

At the same time, fuel surveys should be published and based on grade classifications and not on unrealistic service class numbers.

The net effect of bringing order out of chaos would be to have available: (1) a fuel for intra-city bus operation (an optional 50 F max 90% point requirement to the proposed 1-D grade will prove most satisfactory), (2) a true 1-D grade fuel with revisions as proposed, to provide an optimum fuel for inter-city bus operation, low temperature, or other critical performance areas, (3) and a true 2-D grade fuel having a maximum heat value and a low price for railroad service, and diesel engines in trucks, construction equipment, and industrial service.

To Order Paper No. 74A . . . on which this article is based, see p. 6.

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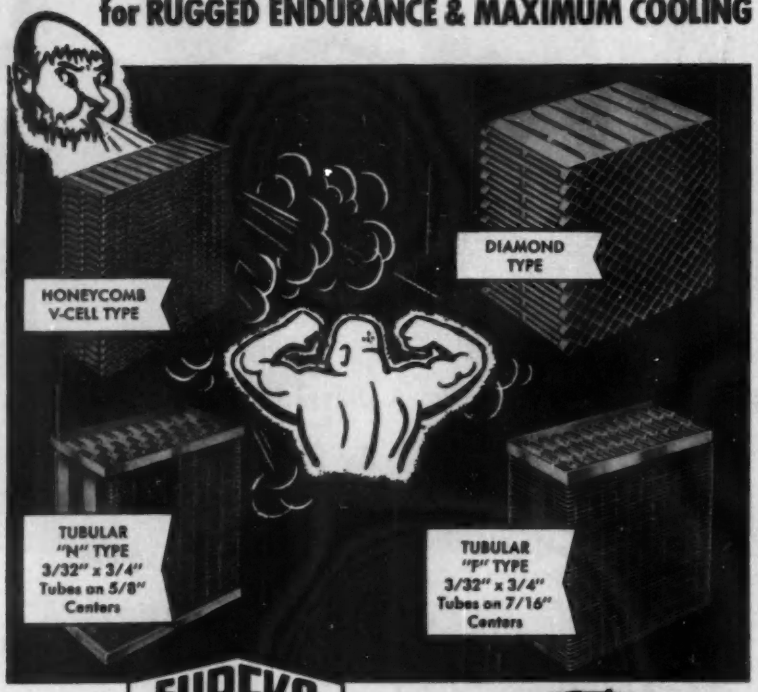

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Evaluating Tractor Steering and Traction

Based on paper by

W. J. ADAMS, JR.
Food Machinery and Chemical Corp.

LOW-SPEED drawbar tests of rubber-tired and crawler vehicles on macadam, loose ground, and mud showed the geometrically steered, four-wheel drive and steer vehicles approaching most closely the drawbar characteristics of crawler vehicles. The frame-steered wheel vehicle showed a superiority in its ability to traverse mud.

These were findings of steering and traction tests employing a research vehicle designed for quick change to evaluate 17 drive and steering combinations and thus reduce to a minimum vehicle and test parameters and variables.

Other results of these tests were:

• High-speed tests on macadam showed the geometrically steered vehicles to be superior to the skid-steered wheeled vehicles.

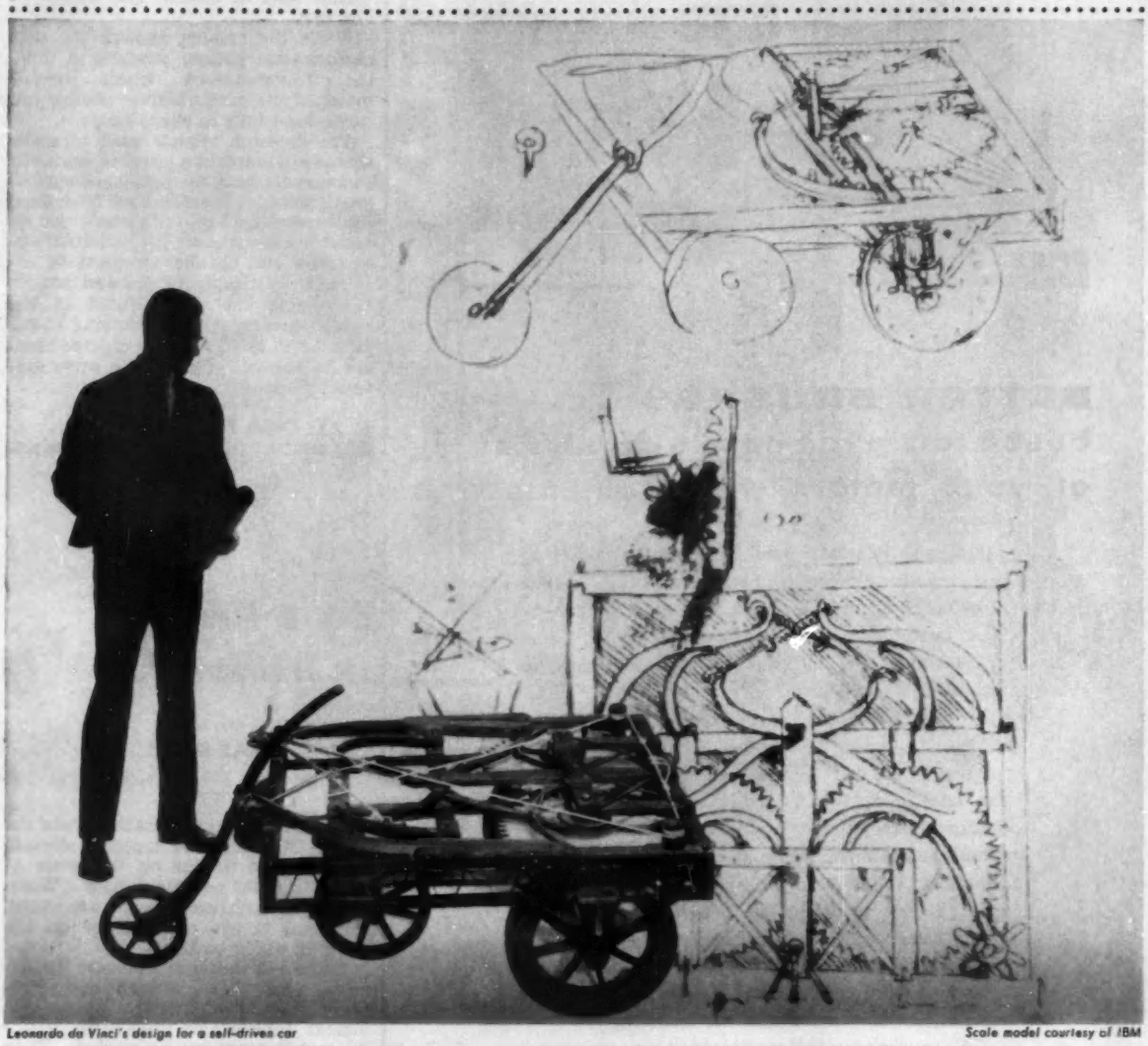
• The variable-ratio type, skid-steer drive comes the closest to approaching the pulling and steering characteristics of the geometrically steered vehicle.

• The skid-steered wheeled and crawler vehicles demonstrated their basic superiority in turning in less space than geometrically steered, four-wheeled and two-wheeled vehicles.

During mud tests the frame-steered vehicle was observed to be capable of traversing mud better than either the four-wheel steer or skid-steer versions. This is attributed to the ability of the

continued on page 136

creative designing calls for an open mind



Leonardo da Vinci's design for a self-driven car — *Scale model courtesy of IBM*

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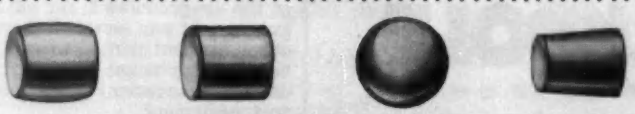

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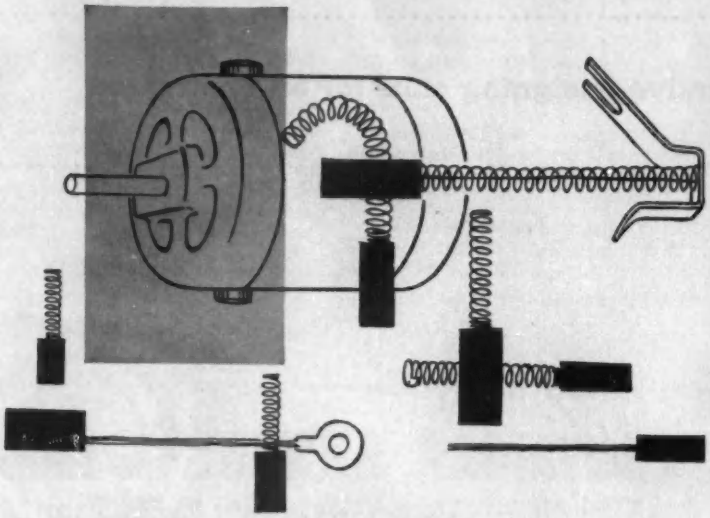

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Most of our recommendations are based on extensive tests of the actual motorized equipment in the Stackpole laboratories. Specific motor operating conditions and specified performance objectives are fully considered. Variables taken into account include rpm., service load, desired brush life, permissible commutator wear, acceptable noise levels, contaminating atmospheric influences, temperature rise and others. Brush grade and brush mechanical factor recommendations are then made accordingly.

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continued from page 134

frame-steered vehicle to be jack-knifed or wiggled to place the wheels forcibly into new and different traction spots, whereas with other arrangements the wheels tend to remain and wallow in one spot.

While the crawler showed the best performance pulling straight in mud, the frame-steered wheel vehicle matched its performance pulling on turns, especially in sharp turns.

The research vehicle used to make these tests employs a gasoline engine in combination with two variable displacement hydraulic pumps and four fixed displacement hydraulic motors, one on each driving wheel. By combinations of series and parallel connections between the hydraulic pumps and motors, by varying the displacement of the pumps, and by different valving of the circuits, it is possible to change from one to another of the basic drive systems in a matter of seconds.

To Order Paper No. 79A . . . on which this article is based, see p. 6.

How to Make Jet Transports Pay

Based on paper by
RAY D. KELLY
United Air Lines, Inc.

DOMESTIC direct operating costs for the DC-8 and 707 types of aircraft as estimated will be on the order of $1000 to $1200 per flight hour. When reasonable overhead charges are added, the total hourly cost will be on the order of $1800 to $2000.

These calculations emphasize the absolute necessity for efficient and effective operation. These transports have almost unbelievable productive capacity and it must not be wasted. They promise to produce their superior product at unit costs which will not differ significantly from that achieved with current large piston aircraft, provided they have good load factors and are flown over distances permitting them the advantages of their high-speed capabilities. Daily utilization must be high, and ground operations must be geared up to make certain the airplane is ready to perform whenever needed.

The product this new "machine tool" of the air produces is far advanced in quality over any service hitherto available. Its contribution to progress will be more significant than any previous design advancement in civil air transport equipment.

To Order Paper No. 86A . . . on which this article is based, see p. 6.

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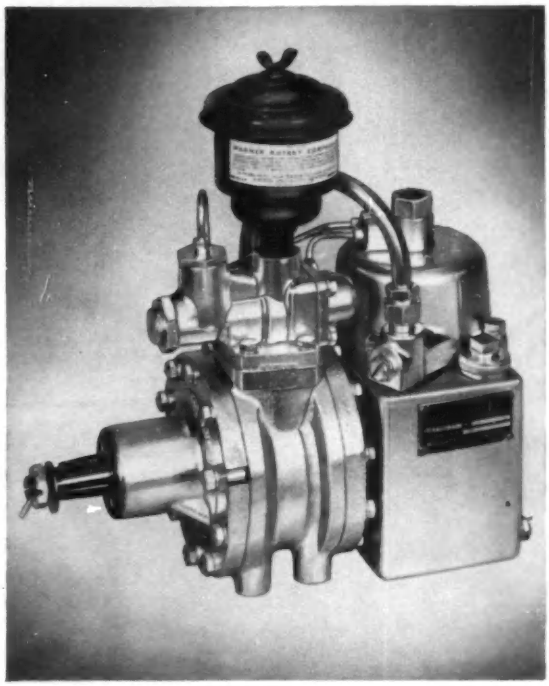

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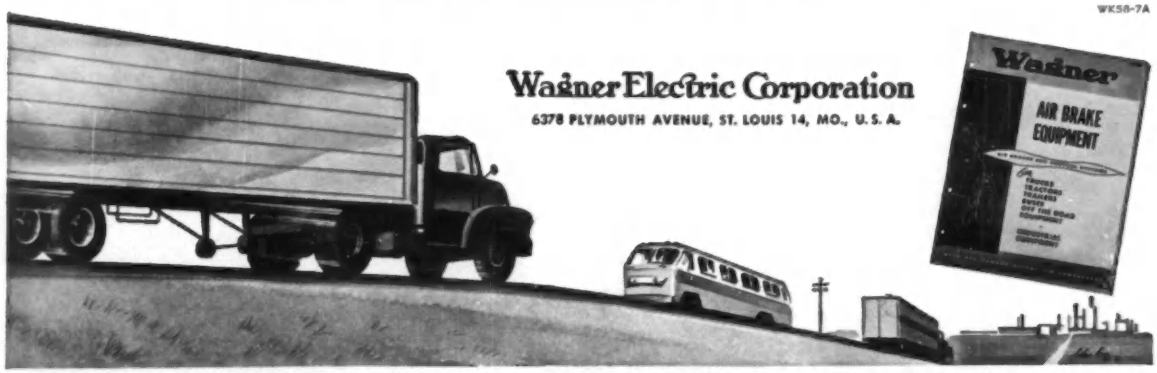

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Buffalo Section

Samuel Egnot (A).

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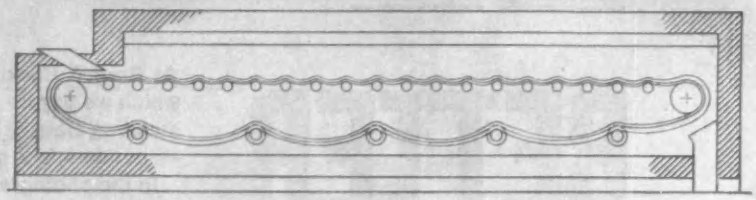

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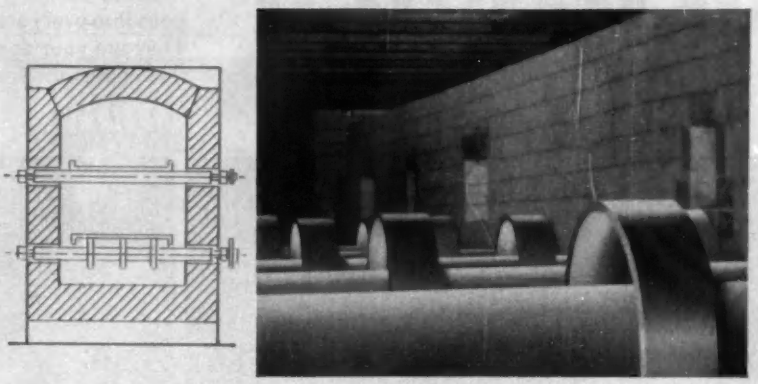

HOLCROFT PATENT DROPS CONVEYOR FURNACE COSTS

Holcroft engineering has done it again! This time to effect a reduction of up to 75% in *original* conveyor furnace belt costs. And years of rigorous testing under actual operating conditions proves that you'll get longer belt life, to boot. The key? Holcroft's exclusive, *patented* (#2,780,454) conveyor belt supporting and driving system . . . a system utilizing driven, synchronized support rollers under both load bearing and return sections of the conveyor belt in conjunction with end drums which function primarily as idlers. No tension is required to move the belt . . . total belt tension is confined to that developed by the load between rollers . . . take-up devices, ordinarily required to tighten belt between end drums, are unnecessary. These advantages permit the use of low-cost, lightweight conveyor belting. And it will last and last even under rugged loading conditions . . . as has already been proved in a Holcroft installation of this type where the belt is still going strong, *without* "crankshafting", after five years! Interested? Write today.

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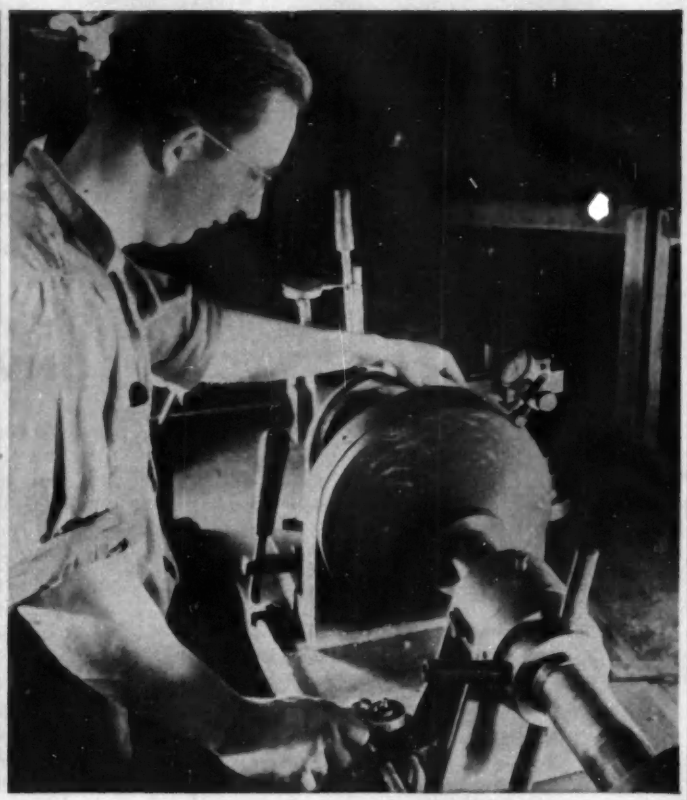
BETTER CLUTCHES

At Borg & Beck, quality control is not just a phrase to which we pay lip service. It is a tradition born of the long-standing Borg & Beck policy of building up to a standard —not down to a price.

In the photograph at the left, for example, release levers are being checked on special equipment to make sure they are parallel with the pressure plate. As shown at the right, every Borg & Beck clutch plate is carefully tested for correct deflection to assure positive release. And every driven plate and cover assembly is dynamically balanced for maximum smoothness of operation.

These exacting tests are typical of the extra care that goes into every step in the making of Borg & Beck clutches. They are your assurance of top quality, top performance, top value. And that means: BETTER CLUTCHES.



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Indiana Section

John Martin McClellan (M), George E. McIntosh (J).

Metropolitan Section

William E. Lovett (J), Frank Marold (M), Benjamin F. Moore (M), Eugene Rocco Roschilla (A), Warren B. Shoag (M), James A. Van Wyk (J), Adolf Vartanian (J), Walter Young (M), Dieter George Eugen Wolff (M).

Mid-Michigan Section

Myron A. Frank (M), O. Franklin Frost (A).

Milwaukee Section

John Robert Bonner (M), Richard Christensen (M), William C. Oswald (M).

Montreal Section

William M. Brownlee (J), Frank R. Richmond (J).

New England Section

Herbert Woodruff Bainton (A), William E. Dowdell (M), H. Joseph Howard (A), Samuel C. Southard (A).

Northern California Section

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Northwest Section

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St. Louis Section

John C. Ryan (A).

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Southern California Section

W. C. Avrea (M), Richard H. Collier (M), Hugh E. Hale (M), Lowell C. Horwedel (J), Hyman M. Kellner (A), Arnold Walter Siegel (J).

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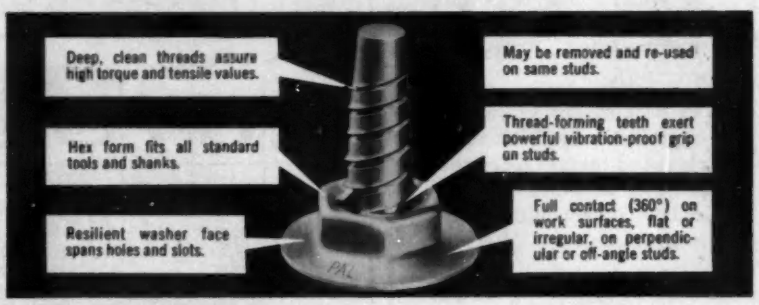
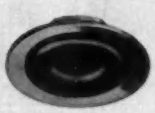
PALNUT® Self-threading Lock Nuts

Make their own threads while tightening

on straight or tapered unthreaded studs, rods, rivets or wire of zinc, aluminum, steel or brass.


Deep, clean threads assure high torque and tensile values.
Hex form fits all standard tools and shanks.
Resilient washer face spans holes and slots.
May be removed and re-used on same studs.
Thread-forming teeth exert powerful vibration-proof grip on studs.
Full contact (360°) on work surfaces, flat or irregular, on perpendicular or off-angle studs.
PAL

Other variations available



Washer, with Sealer Keeps out water and dust.

Washer, Grounding Type. Notches cut thru coatings to electrically ground assemblies.

Regular Hex Type Saves space where no flat washer is required.

Washer, Grounding Type with sealer.

WRITE FOR FREE SAMPLES, details, and prices, stating type, size and application.

PALNUT Self-threading Lock Nuts are low-priced spring-tempered steel fasteners with a special thread-forming, thread-locking design.

Save the cost of threading die-cast studs; also rods and wire, by using low-cost unthreaded parts and fastening with PALNUT Self-threading Lock Nuts. Assembly is easy and fast, using standard tools . . . extra fast using PALNUT magnetized wrenches.

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New Members Qualified

continued

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Edward K. Dunnett (M), Adolph M. Stejskal (M), David E. Stover (J).

Foreign

Dr. Ing. Heinz W. Balster (M), West Germany; Ralph Day (M), So. Africa.

Applications Received

The applications for membership received between August 10, 1958 and September 10, 1958 are listed below.

Baltimore Section

Robert E. Cook

Canadian Section

William James Abrams, Robert John Eames, Edward Halas, Lawrence A. Hendren, J. Barton Lewis, A. C. Mast, William Bruce McLean, Robert Earl Woolcott

Central Illinois Section

Gerald Junior Bright, James L. Hopper, Gerald F. McDonough, Shairyl I. Pearce, R. Dale Philipsen, William R. Thomas, Donald Richard Weaver

Chicago Section

Rudolph Bodemuller, Frank Budreck, Robert Roy Coons, Robert C. Eccli, Theodore O. Elsner, Awad S. Hakeem, Paul H. Harrer, Donald E. Kuska, Charles W. Kyte, William W. Sabin, Jaroslau Sarapuk, Joseph P. Steger, Edward A. Swanson

Cincinnati Section

Laurence R. Woodward

Cleveland Section

Abe J. Hanje, Clark H. Hofmann, James A. Novak, Karl F. Reed, Jerald Joseph Rimlinger

Dayton Section

Richard J. Becht, Capt. Arthur Madison Casbeer, Ronald F. McCann, Ferdinand M. Trobridge

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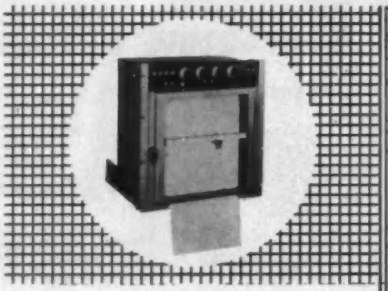
AUTOGRAF trade mark
2 new recorders



MODEL 8
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ADVANCE X-Y RECORDER

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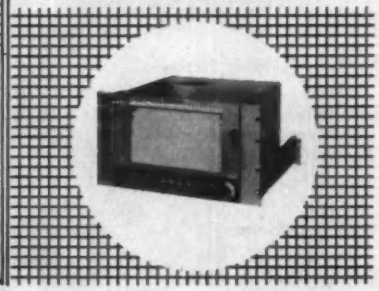

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Laboratory type with PUSH BUTTON control of up to 12 speeds from 60 in./min. to 1 in./hr. Over 100 feet of chart capacity, 10" wide. Multiple span range control with zero offset; 200,000 ohms/volt input resistance.

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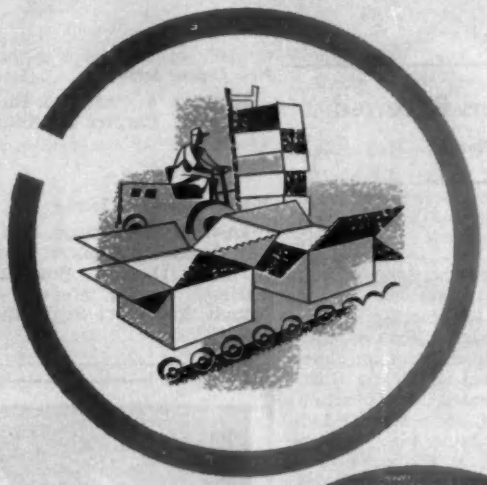
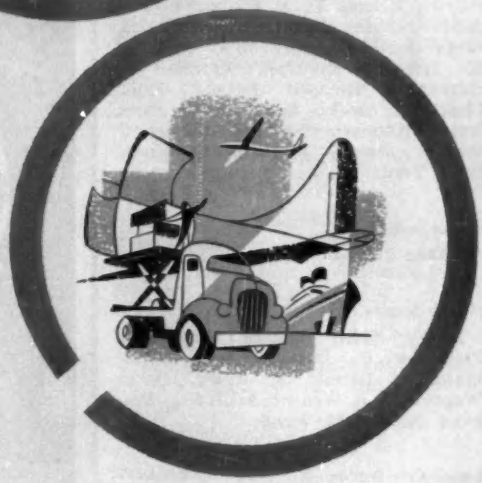
409 N. FAIR OAKS AVENUE, PASADENA, CALIFORNIA





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Hawaii Section

Edwin Cabral

Indiana Section

Henry Keith Arnold, Alan Bott, Frederick C. Brooks, James Dale Matchett, Donald M. Riley, Oskar Wagner, D. A. Weaver, Adolph J. Weigand, Edward M. Wene

Kansas City Section

Keith H. Birkett

Metropolitan Section

H. D. Brown, Carl Carvel, B. A. Certo, Robert Byron Chase, Jr., Kurt S. Ellner, Vito Vincent Gassi, Leonard F. Griffing, Theodore M. Krewski, Henry Anthony Marzullo, Jr., Albert Raynor Mead, Fredrick L. Schaller, Oscar Bernhardt Schier, II, Fred B. Silvan, Kenneth William Sims, James Alexander Spencer, Philip M. Strong, Edward Barr Uhler, T. A. Weiss, Jr.

Mid-Michigan Section

Alfred C. Drouillard, John B. Giacoletti, Lloyd Joel Lee, Jacob G. Stoner

Milwaukee Section

Burzoe K. Ghandi, Howard L. Dahlstrom, James W. Price, Ernst C. Ullius, Robert K. Ruland

Mohawk-Hudson Section

Arthur Frank Campbell, Jr.

Montreal Section

Derek Angus, John Edward Hocking, Richard Neil Patterson

New England Section

Kenneth A. Campbell, Richard Lorn MacLaren, Chester J. Orciuch

Northern California Section

Lawrence E. Atwood, Matthew Tenney Campbell, Edgar F. Cronin, Lewis M. Gibbs, David K. Homan, Frank W. LaHaye, Joseph Meyers, Wallis K. Mundt, Eugene D. Sweetland

Northwest Section

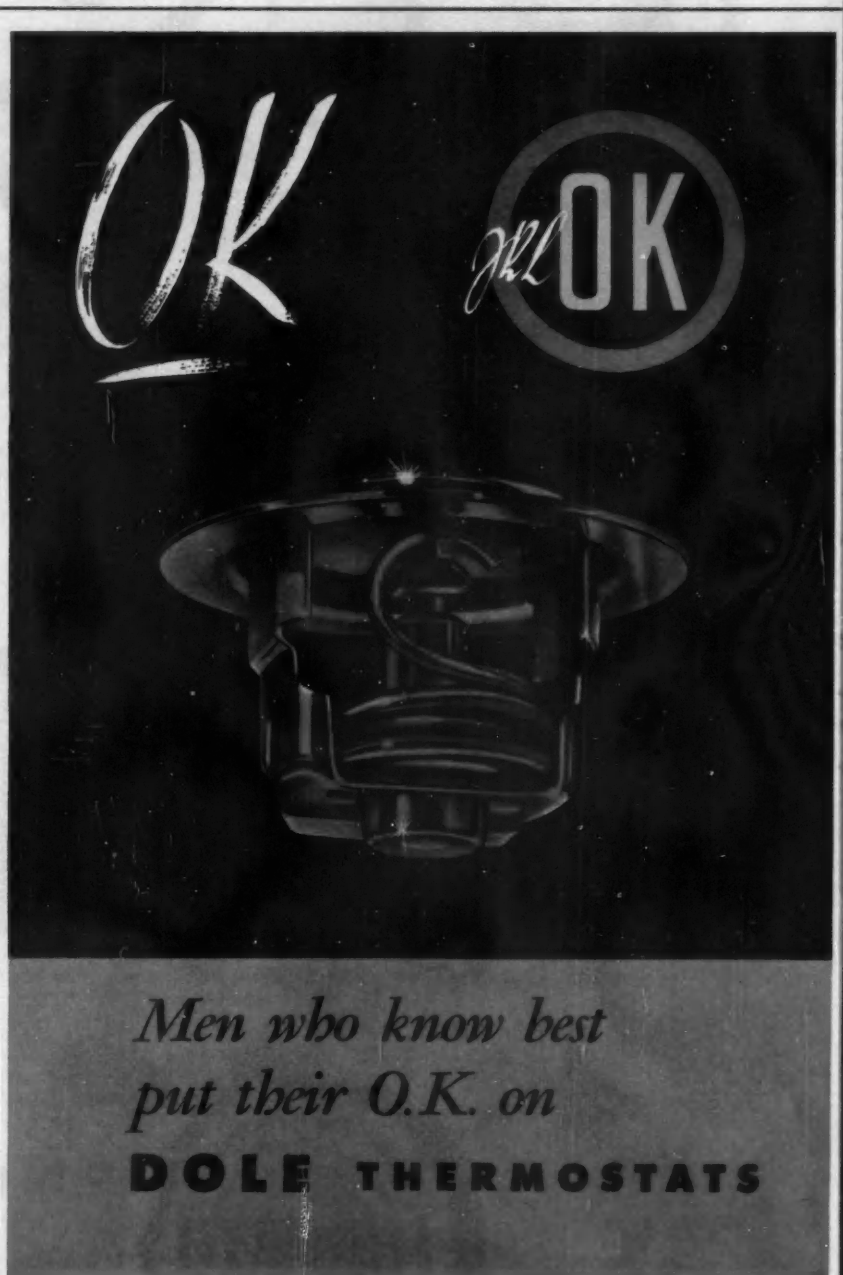
John William Culpepper, Paul J. Durning, Robert Allen Foseid, Gerald Grant Johnson, Norman L. Nesbit

Oregon Section

Victor V. Cox

Philadelphia Section

George A. Krail, Jr., R. Edward Lo-



dico, Ronald Clarke Miller, Donald H. Thomas, Gerald H. Zimmerman

Pittsburgh Section

Harry J. Dell, Charles Kerr, Jr., David Lunifeld, Ronald L. McCafferty, Eugene John Pasquinelli, Thomas E. Rodwick, Joseph Gaber Scott, Edward E. Woodrow, Benjamin S. Yaffe

St. Louis Section

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Salt Lake Group

Rex Dwane Matesen, Melvin Clarke Taggart

San Diego Section

Emmet Howard Christensen, John Whittington McGruer, Dr. Daryl G. Mitton, Clifford E. Parver, Donald D. Shirk

Southern Texas Group

Heinz Gunter Buschfort

Southern California Section

Russell B. Boyer, Wendell F. Deeter, Walter Eugene Edelman, Jr., Allen H. Fink, Boland Golestan, Thomas Edson Hickoff, Jr., Erwin Raynor Johnson, Richard E. Keeffe, W. J. Koerner, Roger L. Mackenstadt, Paul Lloyd Mohnkern, George S. Nakamura, James Barr Pentecost, William C. Petty, James Benham Pray, Robert Wilson Rouse, William Herbert Sarjeant, Nevel Frank Vanover, Jr.

Southern New England Section

Alan Dubrow, Bruce Joseph Dunbar, Langdon G. Johnson, Martin Macklin, Thomas A. Mroz, Jay S. Tupper

Spokane-Intermountain Section

Harold J. Borneman, Walter Z. Davis

Texas Section

C. H. Rose, John P. Thomas

Twin City Section

William Louis Bruggeman, Jr., Ahmed A. Dadi, M. B. Green, E. H. Harms

Washington Section

Donald Eugene Tempesco

Western Michigan Section

John Robert Sheringer

Williamsport Group

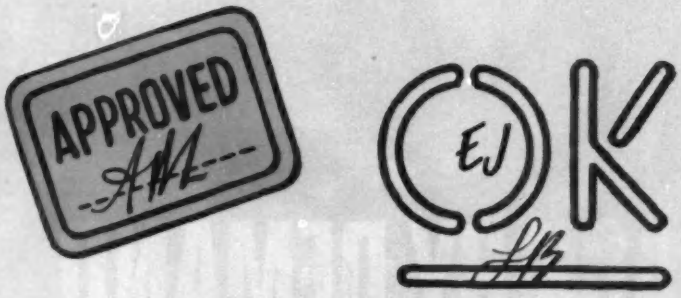
S. Allan Westman

Outside Section Territory

Anthony J. Bender, Glenn R. Bishop, Edward J. Buekers, Myron E. Fredenburg, Donald James Garcia, Thomas E. Harmon, Russel Lloyd Holm, George R. Jedlicka, Owen Thomas Tolson, Jr., Gonzalo Tornell, Jr., Arthur R. Webb, Robert C. White, J. F. Whitlow

Foreign

Major G. C. Brady, Pakistan; C. W. E. Cary, England; Major Frederick William Harding, Pakistan; Victor Hamoushe, Lebanon; Claude Hill, England; Donald Henry Peebles, Australia; Kul Bhushan Rai, India; Rasam C. V. Rao, India; V. V. V. Surya Prakasa Rao, India; Vadali P. Sarma, India; Harbhajan Singh, Germany



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*As listed in Automotive News.

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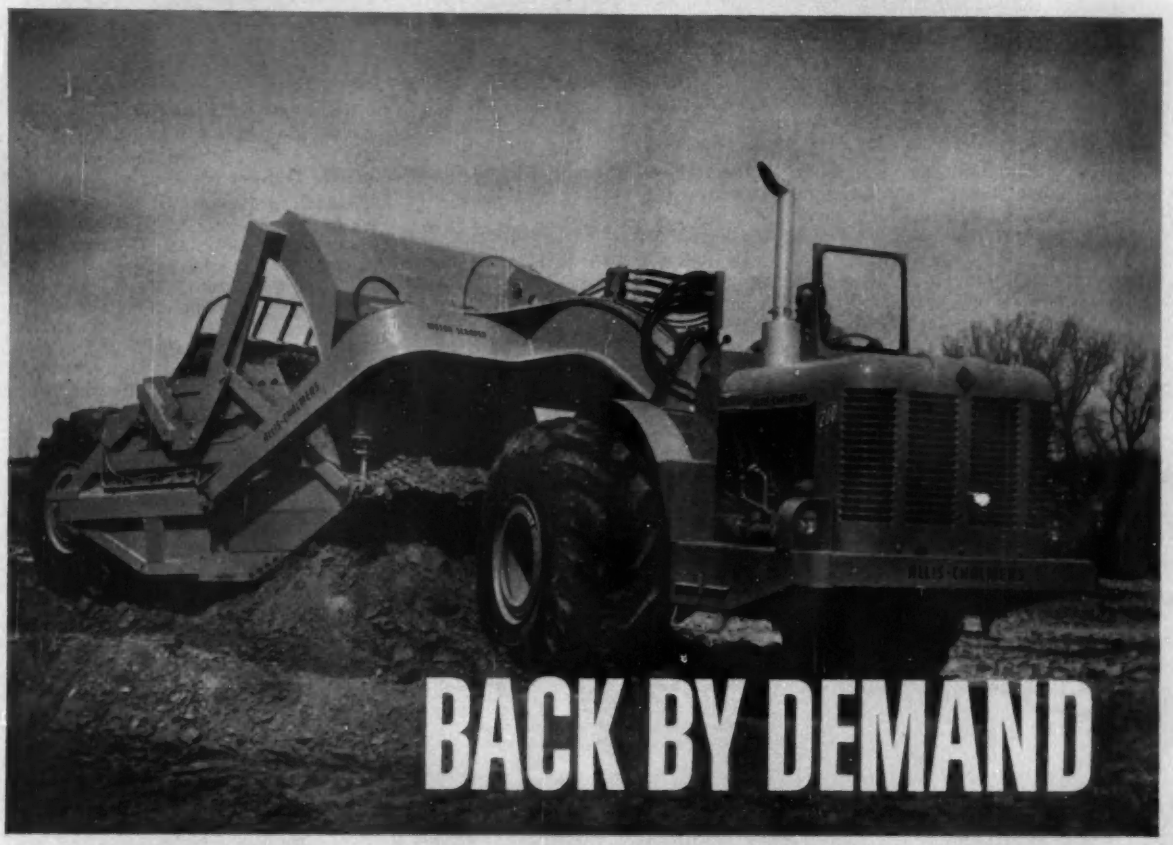

where big loads keep moving!

Firestone Perma-Tite Rims with unique air seal design that gives you absolute tire protection!

Exclusive Perma-Tite design makes rim completely airtight when tubeless tire is mounted, insures a *permanent* air seal for absolute tire protection. Special fusion-welding helps make Perma-Tite Rims the strongest you've ever used. Firestone Steel Products Company's balanced weld gives equal penetration throughout the section. Stress-testing results in removal of non-functional weight, allows reinforcement at high strain points. It's the truest rolling rim you can own—gives 100% tire support, reduces sidewall flexing, lets tire run cooler for longer service. Specify Firestone Perma-Tite Rims as original equipment, buy them as replacements. They're available for tubeless or tubed off-the-highway tires.

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INTERCHANGEABLE in complete units or by components with all Earth Mover Rims and parts.

COMPLETE AIR SEAL insures retention of air at recommended pressures.

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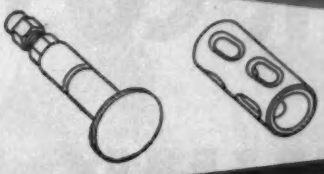

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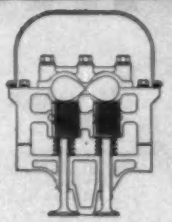
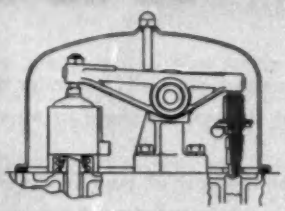
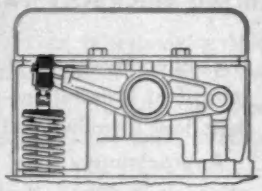
Hydraulic and Mechanical Tappets (Barrel or Mushroom Type) of Alloy Steel, Hardened Alloy Cast Iron, Chilled Iron, or Alloy Chilled Iron • Push Rods • Adjusting Screws



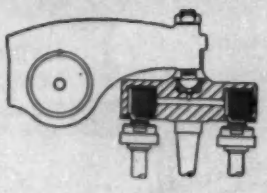
Hydraulic Inverted Cup Type Unit



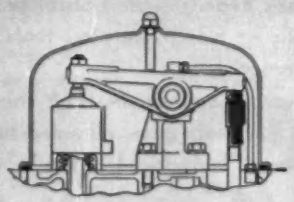
Push Rod Type with Compression Release Application



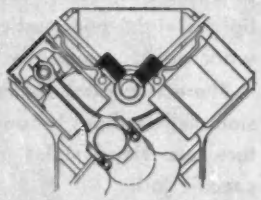
Threaded Type Rocker Arm Unit



Dual Valve T-Bridge Hydraulic Application



Hydraulic Unit on End of Push Rod



V-8 Automotive Hydraulic Tappet Application

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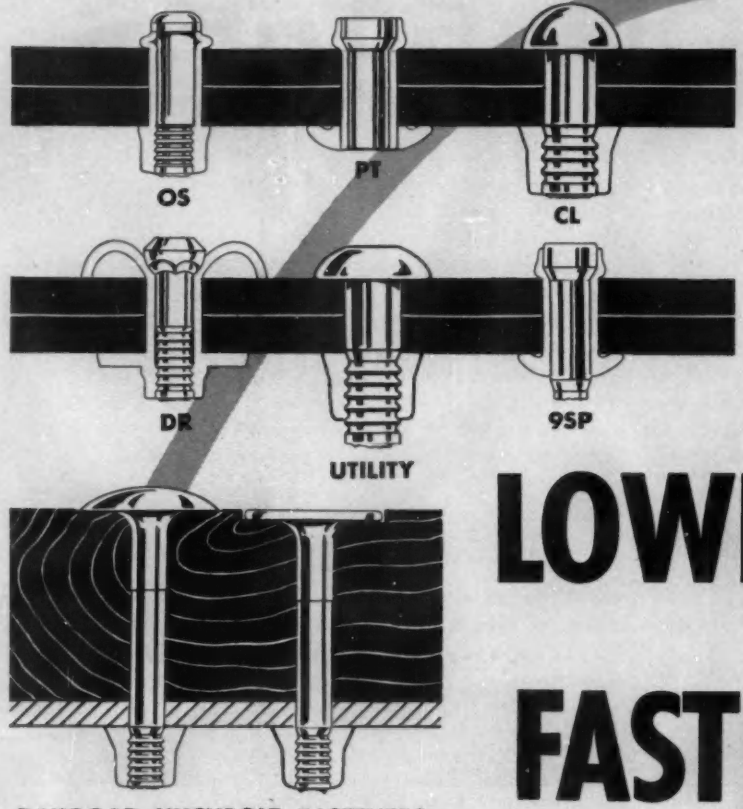

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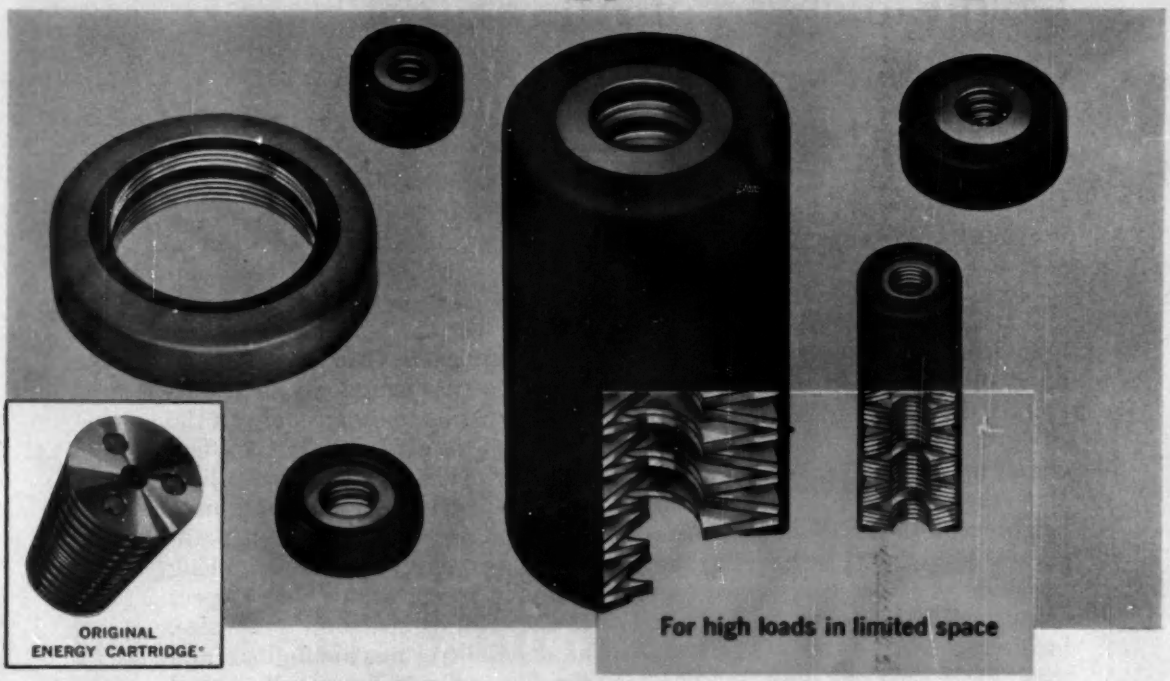
ANNOUNCING... Flexi-Pak ELASTIC-COVERED* Energy Cartridges*



Preassembled belleville spring washers are now available in elastic-covered units in addition to those held together by rivets. Known as Flexi-Pak, molded coverings of rubber, neoprene, or other elastic material can be applied with the washers under tension, or latex coating can be applied under no-load conditions. In either case, washers form integral spring units for applications involving heavy loads in limited space.

Designed for use on washers with narrow walls, or where there are clearance restrictions, the elastic covering insures correct installation or removal of the washers assembled in any sequence. (See cutaway illustration above.) This is especially important where washers are stacked in varying sequence.

As a companion to the previously announced Energy Cartridge held together with rivets or pins through the neutral axis, the elastic-covered units add to the versatility of this increasingly useful type of heavy-duty spring for stripper or die use, machine mounts and drives, constant-force applications, etc.

A.S.C. Divisions are ready to help you use this versatility to advantage with Energy Cartridges tailored to your needs. For more information, write for "Flexi-Pak" folder.

*Patents—Energy Cartridge—U. S. #2,482,449
Elastic-Cover—U. S. #2,432,717

Associated Spring Corporation

General Offices: Bristol, Connecticut

Wallace Barnes Division, Bristol, Conn. and Syracuse, N. Y.
B-G-R Division, Plymouth and Ann Arbor, Mich.
Gibson Division, Chicago 14, Ill.
Milwaukee Division, Milwaukee, Wis.
Raymond Manufacturing Division, Corry, Penna.
Ohio Division, Dayton, Ohio
F. N. Manross and Sons Division, Bristol, Conn.
San Francisco Sales Office, Saratoga, Calif.
Seaboard Pacific Division, Gardena, Calif.
Cleveland Sales Office, Cleveland, Ohio
Dunbar Brothers Division, Bristol, Conn.
Wallace Barnes Steel Division, Bristol, Conn.
Canadian Subsidiary: The Wallace Barnes Co., Ltd., Hamilton, Ontario and Montreal, Quebec

9834

XXIX *This is the twenty-ninth of a series of advertisements dealing with basic facts about alloy steels. Though much of the information is elementary, we believe it will be of interest to many in this field, including men of broad experience who may find it useful to review fundamentals from time to time.*

Cold-Finishing of Alloy Steel Bars: Grinding and Polishing

Grinding and polishing of cold-drawn or turned alloy steel bars is the concluding discussion on the subject of cold-finishing. In the processes of turning and polishing, and grinding and polishing (both of which require removal of surface metal), the surface finish of the bars, as well as their dimensional accuracy and alignment, are improved. But the ultimate in quality of bright, smooth surface finish and accuracy is produced by grinding and polishing of either cold-drawn bars or turned bars up to 4-in. diam, inclusive.

GRINDING AND POLISHING

Sizes up to and including 4-in. diam, are generally confined to centerless cylindrical grinders. Larger sizes are ground on centers. A centerless grinder includes a grinding wheel, a regulating wheel for applying pressure against the bar, and a work-rest blade which both supports the bar and guides it between the wheel spacing. Automatic feed of the whole length of the bar is accomplished because the regulating wheel is set at an angle of inclination with respect to the grinding wheel, and thus within this system the bar rotates and feeds during grinding. The bar is then polished to a mirror-like finish by passing through straightening rolls.

Both processes of turning and polishing, and grinding and polishing, are applicable to normalized, annealed, or heat-treated carbon and alloy bars. These operations do not materially affect the mechanical properties. For this reason, the end product can be machined unsymmetrically, with little or no tendency to warp.

Fundamentals Only. In the past four advertisements, we have outlined *basic fundamentals only* on the cold-drawing of alloy bars, the effect of cold-drawing, turning and polishing, and grinding and polishing.

Please keep in mind that Bethlehem metallurgists have given long study to specifications with respect to chemical composition, grain size, hardenability, machinability, and the like, of cold-drawn alloy steel bars. If you would like additional information on cold-drawn products, or alloy steels, our metallurgists will gladly give you all possible help, without cost or obligation.

When you are ready for new supplies of alloy steels, Bethlehem can offer the full range of AISI standard grades, as well as special-analysis steels and all carbon grades.

If you would like reprints of this series of advertisements, please write to us, addressing your request to Publications Department, Bethlehem Steel Company, Bethlehem, Pa. The subjects in the series are now available in a handy 40-page booklet, and we shall be glad to send you a free copy.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

L. E. Erlewine, Supt. of Motor Maintenance WATSON BROS. says:

"We get 6000 to 8000 miles of EFFECTIVE FILTRATION from a single DIESELPAK"*

Here's powerful proof that superior performance COSTS LESS than ineffective substitutes

Only LUBER-FINER DIESELPAK, with its *exclusive* specially processed media, removes oil contaminants *effectively*—FAR LONGER THAN ANY SUBSTITUTE PACK.

DIESELPAK—designed expressly for use with H.D. detergent compounded oil—removes not only injurious suspended solids, but also colloidal impurities (often more destructive) *without affecting the additives.*

Thus LUBER-FINER DIESELPAK

1. COSTS LESS than ineffective substitutes because it gives MORE MILES of *effective filtration.*
2. Also ADDS THOUSANDS OF MILES to ENGINE AND OIL LIFE because its exclusive engineered protection CLEANS OIL FASTER AND KEEPS IT CLEAN LONGER.

STANDARD AND OPTIONAL EQUIPMENT—On leading Diesel Trucks, Tractors and Stationary Engines.

* A typical statement of many users, engineers, and original equipment manufacturers on file.

VISUAL PROOF why DIESELPAK is The Standard of the Industry

Positive end seals prevent the oil from by-passing. The oil is filtered through the patented media of the DIESELPAK which removes colloidal particles and other contaminants without adversely affecting the additives.

The oil then passes through several layers of protective fibrous material which is scientifically engineered to positively prevent media from migrating into the engine.

World renowned engineered protection is enjoyed only by the users of the genuine LUBER-FINER "DIESELPAK."

Luber-finer

WRITE FOR INFORMATION—how to get MORE MILES of effective lubrication at LESS COST. Dept. F-2.

LUBER-FINER, INC.
2514 South Grand Avenue, Los Angeles 7, California

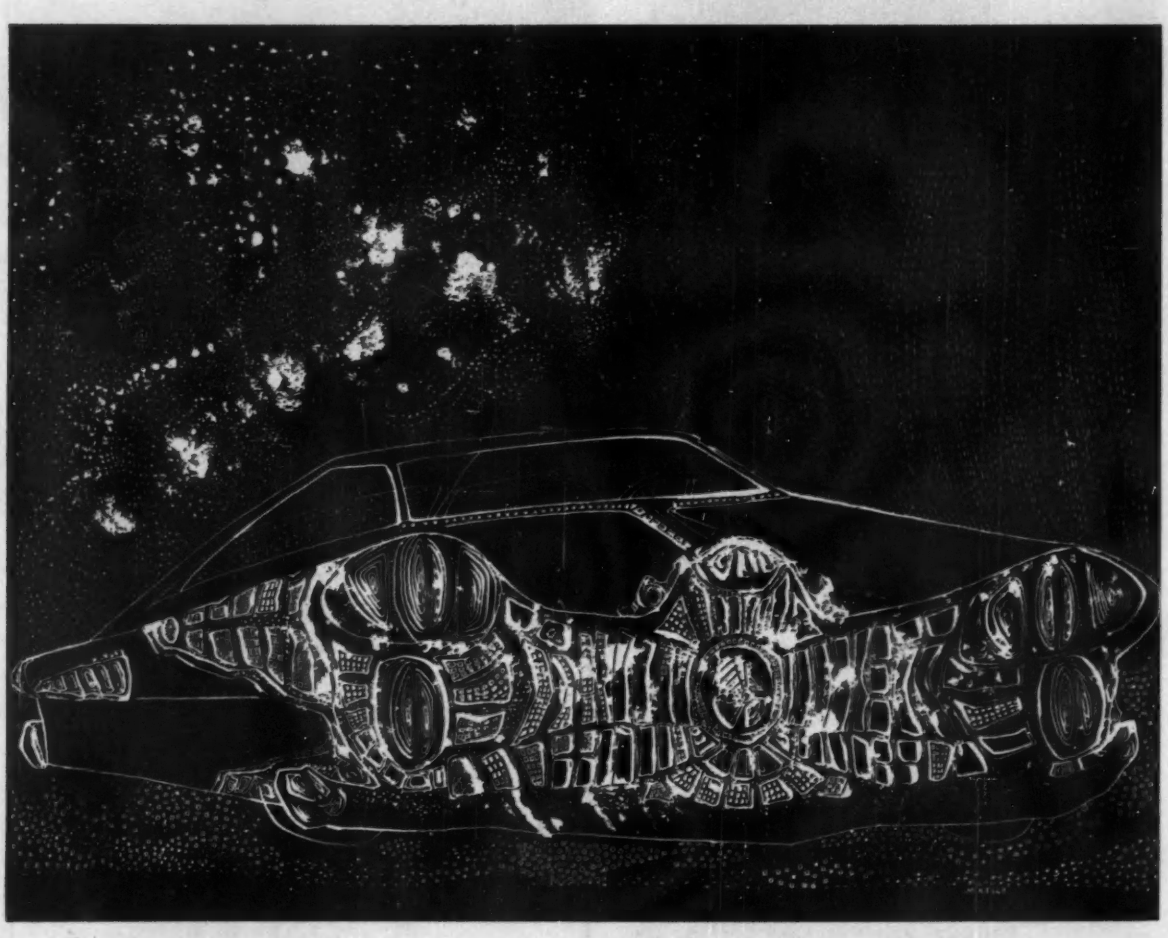
nightmare alley

If a car could dream, what stuff would its nightmares be made of? Untranquilized, tossing feverishly in its carport, it would fall prey to that ramshackle specter that haunts all denizens of the road. From its mechanical libido would emerge boogermen built of road salt, sea air, sand storms and freeze . . . enough to frighten any motor car right out of its trim.

Save that tender, quaking soul! Insure Valhalla by prescribing a liberal dose of Stainless Steel to last a lifetime . . . and to last without the bother of pads, polishes or protective fluids.

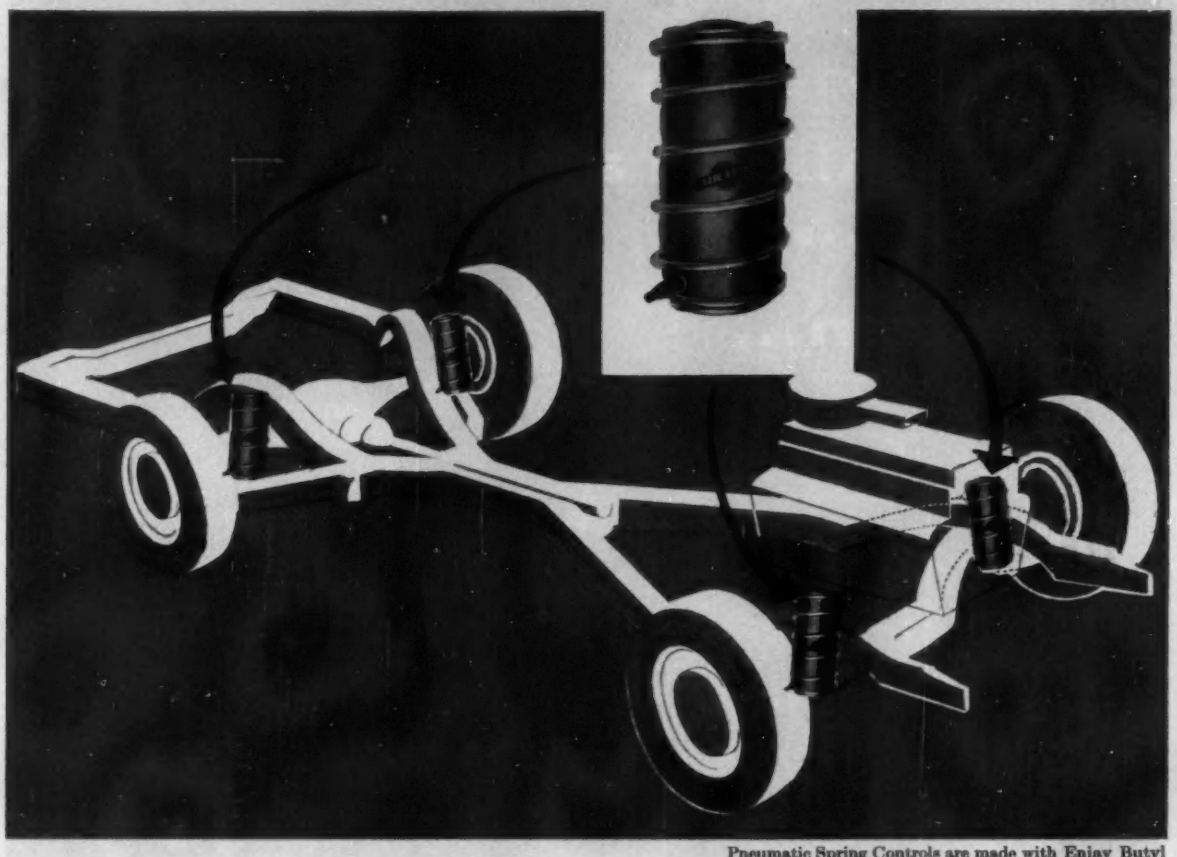
Actually, you'll be doing yourself a favor because Stainless Steel has sales appeal! Trim your new model with copious quantities of Stainless Steel and *tell* your customer about it. He already knows what a miracle metal Stainless is, but may not know that there is any on your car. As for yourself, you're surely aware that Stainless Steel trim often costs less than other materials because there are fewer fabricating steps, you can use thinner gages because it is so strong, and there is no need to overdesign to allow for corrosion or impact damage.

USS is a registered trademark



United States Steel Corporation—Pittsburgh
American Steel & Wire—Cleveland
National Tube—Pittsburgh
Columbia-Geneva Steel—San Francisco
Tennessee Coal & Iron—Fairfield, Alabama
United States Steel Supply—Steel Service Centers
United States Steel Export Company

USS **United States Steel**



Pneumatic Spring Controls are made with Enjay Butyl to provide quieter, softer cushioning in automobiles.

ENJAY BUTYL

actually lets you ride on air!

Enjay Butyl Rubber is used by the Armstrong Rubber Company, West Haven, Connecticut, in the production of Air Lift Pneumatic Spring Controls for the Air Lift Company, Lansing, Michigan. Butyl Air Lift units are inserted between leaf spring and frame to support overloads and cushion all moving parts of suspension. Inflatable to meet load requirements, these units protect vehicles–provide a smoother, safer ride.

Each week the Armstrong Rubber Company turns out thousands of Air Lift units made from Enjay Butyl Rubber. They chose Enjay Butyl because of its superior air retention and resistance to aging. Since tough, weatherproof Butyl is low in cost, it may be the answer to lower production costs for you. For complete information and expert technical assistance, call or write the Enjay Company.

ENJAY
BUTYL

Enjay Butyl is the greatest rubber value in the world. It's the super-durable rubber with *outstanding* resistance to aging • abrasion • tear • chipping • cracking • ozone and corona • chemicals • gases • heat • cold • sunlight • moisture.

Pioneer in Petrochemicals

ENJAY

ENJAY COMPANY, INC., 15 West 51st Street, New York 19, N. Y.

Akron • Boston • Charlotte • Chicago • Detroit • Los Angeles • New Orleans • Tulsa

AiResearch centralized air data computing system...

on Navy's new McDonnell F4H-1

...supplying the following major airplane subsystems: Autopilot, Air Induction, Armament Control, Navigation, Surface Controls, Cockpit Indication and Pneumatic Static Pressure Correction.

The AiResearch centralized air data computing system integrates pneumatic, electronic, electrical and mechanical components on one of the Navy's fastest jets. It senses, measures, and automatically corrects all air parameters affecting flight. It supplies air data information to the pilot and all major airplane subsystems.

This centralized combination of transducers, computers and indicators is the most complete air data computing system ever devised. It enables aircraft to operate at maximum efficiency continuously.

Eliminating duplication of components, the AiResearch centralized air data computing system cuts down space and weight requirements over decentralized systems by many times. Its principal functions: angle of attack, true static pressure (electrical and pneumatic), true air speed, true Mach, altitude, rate of climb, total temperature, dynamic pressure and altitude and Mach error.

AiResearch has been the leader in the development of centralized computing systems. The F4H-1 installation is the first, single package air data computer possessing completely interchangeable, modular construction.

Your inquiries are invited.

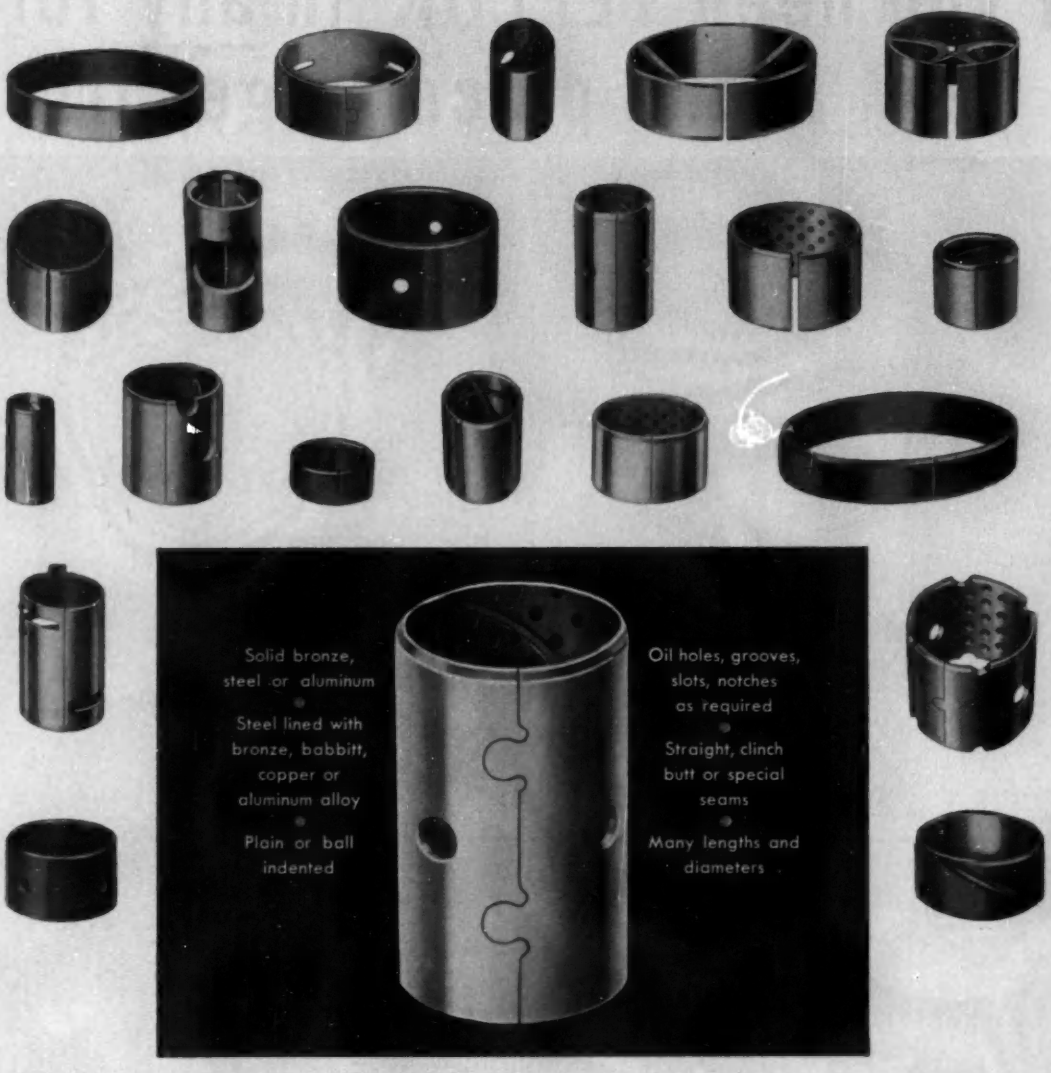
ENGINEERING REPRESENTATIVES: AIRSUPPLY AND AERO ENGINEERING, OFFICES IN MAJOR CITIES

THE GARRETT CORPORATION

AiResearch Manufacturing Divisions

Los Angeles 45, California • Phoenix, Arizona

Systems, Packages and Components for: AIRCRAFT, MISSILE, ELECTRONIC, NUCLEAR AND INDUSTRIAL APPLICATIONS


Solid bronze, steel or aluminum
Steel lined with bronze, babbitt, copper or aluminum alloy
Plain or ball indented
Oil holes, grooves, slots, notches as required
Straight, clinch butt or special seams
Many lengths and diameters

LOW COST BUSHINGS with Bearing Performance!

Bimetal bushings, in a variety of alloys on steel, provide bearing load-carrying qualities, *with the advantages of low-cost production.* Quality-controlled manufacturing to your specifications. Complete engineering service. Write:

FEDERAL-MOGUL DIVISION

FEDERAL-MOGUL-BOWER BEARINGS, INC., 11035 SHOEMAKER, DETROIT 13, MICHIGAN

Copper-Alloy Lined

Spacer Tubes

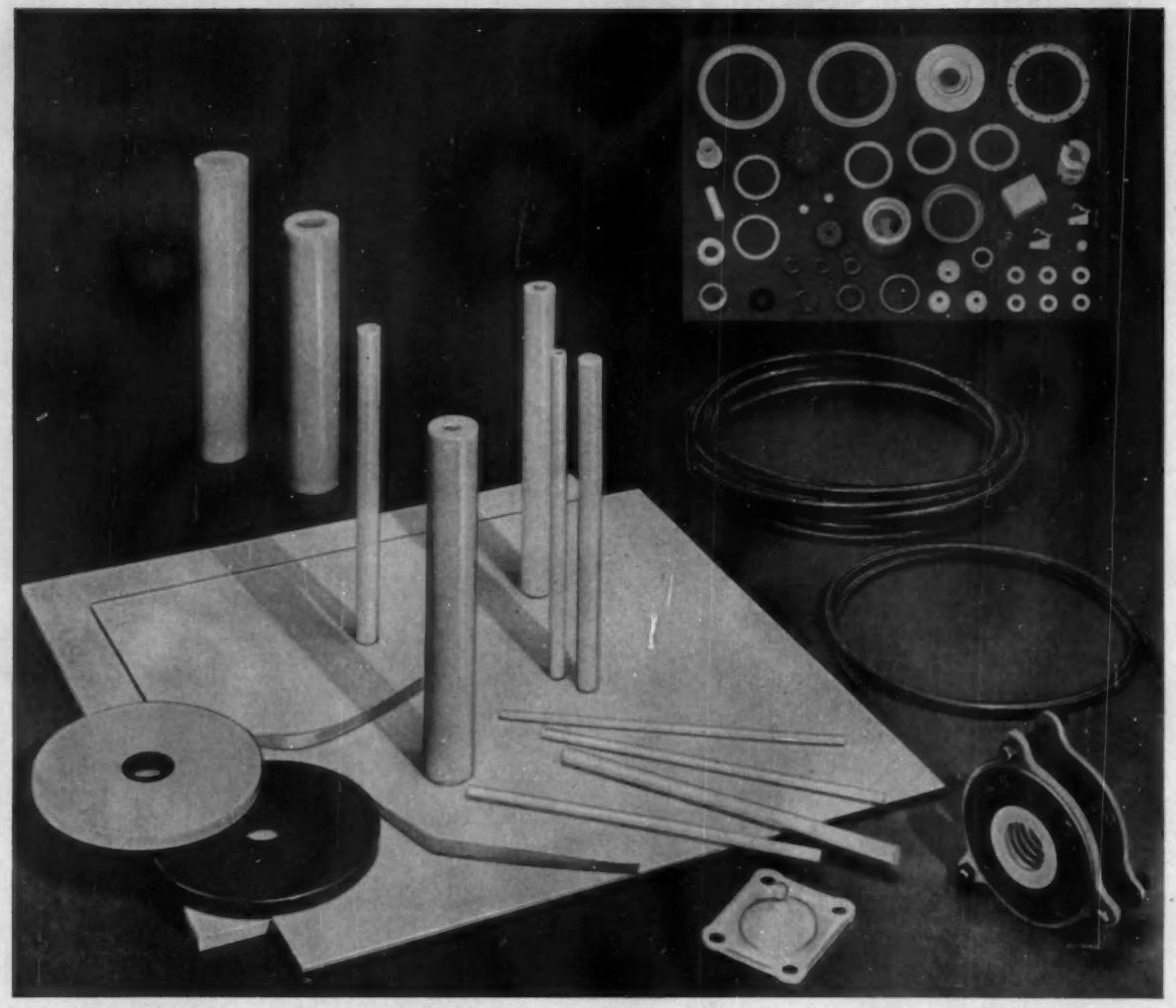
Bearing-Surfaced Thrust Washers

Aluminum or Babbitt Lined

FEDERAL Mogul SINCE 1899

RESEARCH • DESIGN • METALLURGY • PRECISION MANUFACTURING

If you need TEFLON* in any form R/M is the place to get it!



Raybestos-Manhattan pioneered in research and development in the use of "Teflon." R/M has had vast experience in fabricating this amazing substance . . . has accomplished things with it once thought impossible, such as molding highly complex valve diaphragms.

But R/M has more than the know-how—it has the facilities to produce "Teflon" in exactly the form you want it . . . can supply *all* your needs, from the usual types of tubes, tape, rods, sheets and flexible wire braid covered hose to complicated molded and machined parts.

That is why R/M should be your headquarters for all your needs in products made of "Teflon," from simple standardized parts to intricate components painstakingly customized to your specifications. Call on your nearest R/M district office for the cooperation you need. Or write for detailed information.

*A Du Pont trademark

R/M

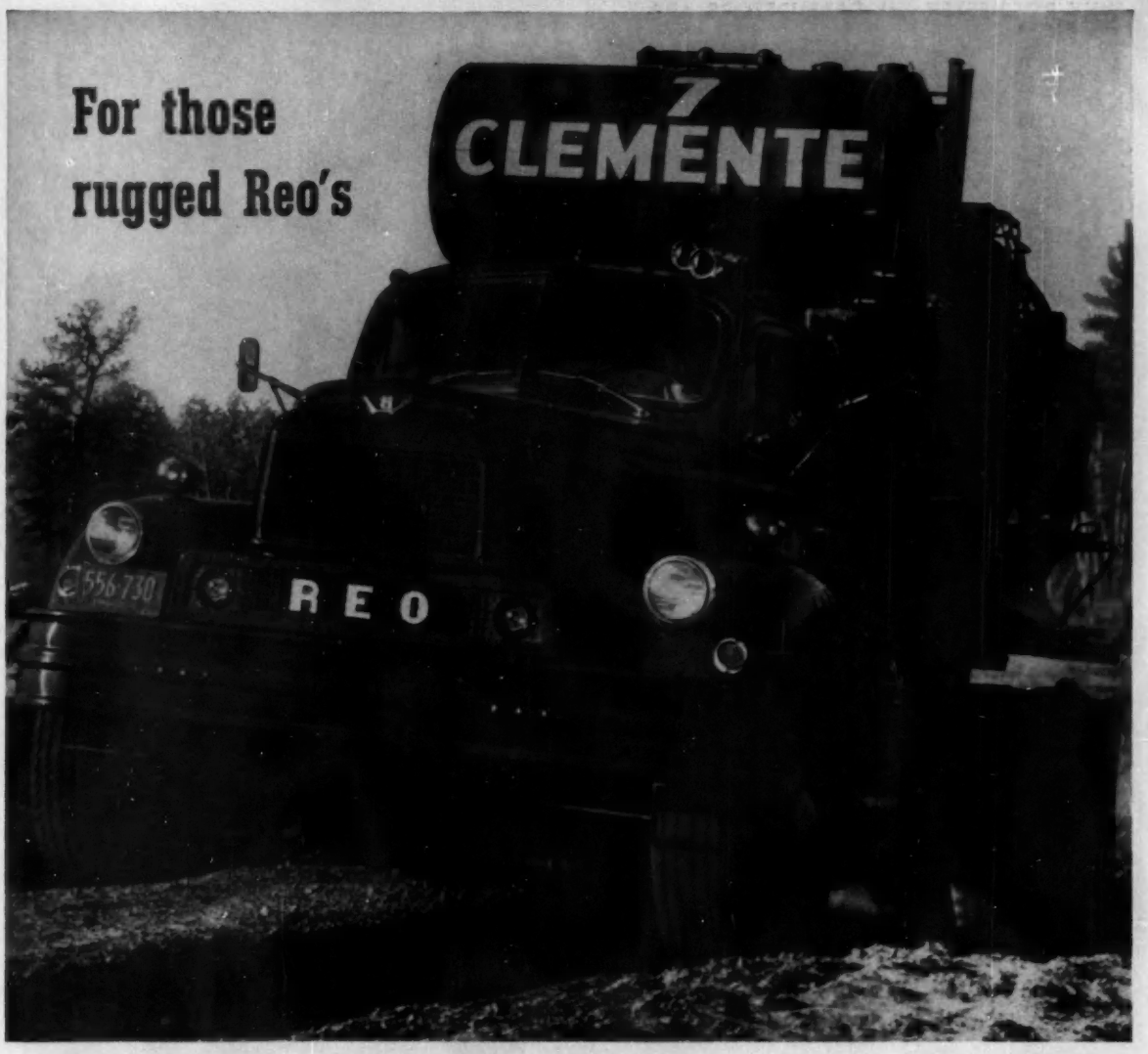
RAYBESTOS-MANHATTAN, INC.

PLASTIC PRODUCTS DIVISION FACTORIES: MANHEIM, PA.; PARAMOUNT, CALIF.

Contact your nearest R/M district office listed below for more information or write to Plastic Products Division, Raybestos-Manhattan, Inc., Manheim, Pa.

BIRMINGHAM 1 • CHICAGO 31 • CLEVELAND 16 • DALLAS 26 • DENVER 16 • DETROIT 2 • HOUSTON 1 • LOS ANGELES 58 • MINNEAPOLIS 16
NEW ORLEANS 17 • PASSAIC • PHILADELPHIA 3 • PITTSBURGH 22 • SAN FRANCISCO 5 • SEATTLE 4 • PETERBOROUGH, ONTARIO, CANADA

RAYBESTOS-MANHATTAN, INC., Engineered Plastics • Asbestos Textiles • Mechanical Packings • Industrial Rubber • Sintered Metal Products • Rubber Covered Equipment
Abrasive and Diamond Wheels • Brake Linings • Brake Blocks • Clutch Facings • Laundry Pads and Covers • Industrial Adhesives • Bowling Balls



Reo recommends Sealed Power KromeX piston ring sets with chrome-cyclan top rings

Reo dealers everywhere can now provide famous Sealed Power KromeX Piston Rings for replacement service. These outstanding KromeX Piston Ring Sets are especially designed, tested and approved to meet the rugged performance requirements of the *world's toughest trucks.*

The cyclan-plus-chrome combination in these rings positively defeats excessive heat, side-wear, breakage, friction and corrosion in applications where other rings fail. They break in fast—last, and last, and last.

Sealed Power Piston Rings are original equipment in Reo trucks.

SEALED POWER CORPORATION, MUSKEGON, MICHIGAN

Sealed Power KromeX Ring Sets

WHY ROCHESTER-GM CARBURETORS ARE

AMERICA'S NUMBER ONE ORIGINAL EQUIPMENT CARBURETORS!

This carburetor plays no "dirty tricks" on performance or economy!

There's not a speck of trouble in a Rochester-GM Carburetor. One reason is the thorough washing float bowls, throttle bodies and air horns get before assembly. Special Centri-Spray circular index washers penetrate every hole to remove every particle of dirt. Rochester-GM Carburetors emerge spick and span, ready to deliver sparkling, trouble-free performance. This is just part of the extra care . . . the extra quality you get in a Rochester-GM Carburetor. And it's another big reason why Rochester-GM Carburetors are America's number one original equipment carburetor. *Rochester Products Division of General Motors, Rochester, New York.*

GM

GENERAL MOTORS

America's number one original equipment carburetors

ROCHESTER CARBURETORS

STRAIGHT TALK TO ENGINEERS

from Donald W. Douglas, Jr.

President, Douglas Aircraft Company

You may wonder what the future holds for the engineer who decides to build his career in the aircraft/missile industry.

In terms of permanent demand, this industry probably requires a greater proportion of engineers to total personnel than any other. Here at Douglas we are now employing more engineers than we did during World War II.

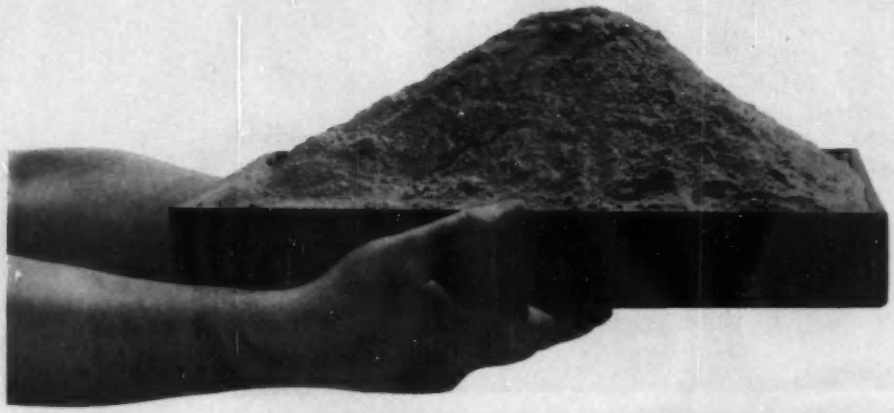
In regard to professional standing, the aircraft/missile industry deals always with the latest state of the art in every engineering and scientific specialty involved. Its engineers are in one of the best informed and highest prestige fields in their profession.

Whatever your present activity, if you decide to move into aircraft, missile and space technology, we would like to talk with you.

Please write to Mr. C. C. LaVene,
Douglas Aircraft Company, Box 620-O,
Santa Monica, California

THIS MUCH DIRT CAN RUIN A DIESEL ENGINE

THIS PUROLATOR FILTER



STOPPED THIS MUCH DIRT

Diesels can't escape abrasive dirt . . . and it takes about 8 ounces of it to ruin an engine.

The 18 pounds of dirt shown above were stopped by a Purolator heavy duty dry type air filter on a rock drilling rig in 940 hours of operation—with no servicing of the filter required. The 6 cylinder, 2 cycle engine and the 750 CFM compressor used on the job were fully protected through the toughest operating conditions. 18 pounds of dirt were stopped . . . none got through the filter.

There's a Purolator dry type air filter designed to meet the specific requirements of your operation. Write today for full information. If you have a particularly tough problem, describe it . . . Purolator has the solution.

Filtration For Every Known Fluid **PUROLATOR**

PRODUCTS, INC.

RAHWAY, NEW JERSEY AND TORONTO, ONTARIO, CANADA

Timken-Detroit "3 for 1" Axles Are First Choice With Big Fleet Operators!

These superior features make the difference:

Interchangeability of Three Final Drives. Single-Speed Single-Reduction, Single-Speed Double-Reduction or Two-Speed Double-Reduction final drives using the same housing, hubs, drums, brakes and axle shafts gives your vehicles unmatched flexibility. Parts are readily available and less expensive.

Hypoid Gears. Larger pinions and greater tooth contact give 30% more torque capacity, top efficiency and long life . . . plus lower maintenance costs.

True Double Reduction. Two full size gear sets, one for each reduction, provide huskier gears and a balanced distribution of effort. Gears and bearings last longer and need less maintenance.

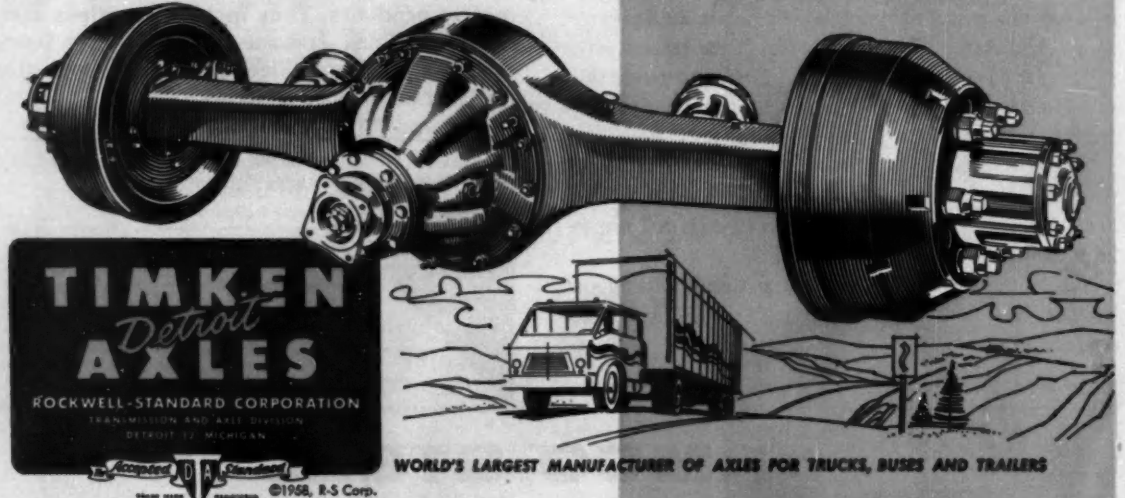
Torsion Flow Axle Shafts. More splines, plus greater root and body diameter, add extra strength.

Famous Time-proved Differential. Extra-strong gear body and teeth, plus hot-forged trunnion, give long trouble-free operation even under the roughest kind of treatment.

Hot-Forged Steel Axle Housing. The rectangular form of these high carbon steel housings is the lightest, strongest shape of housing that is available today.

PROVED AND PREFERRED...

Timken-Detroit® Axles are the Accepted Standard!



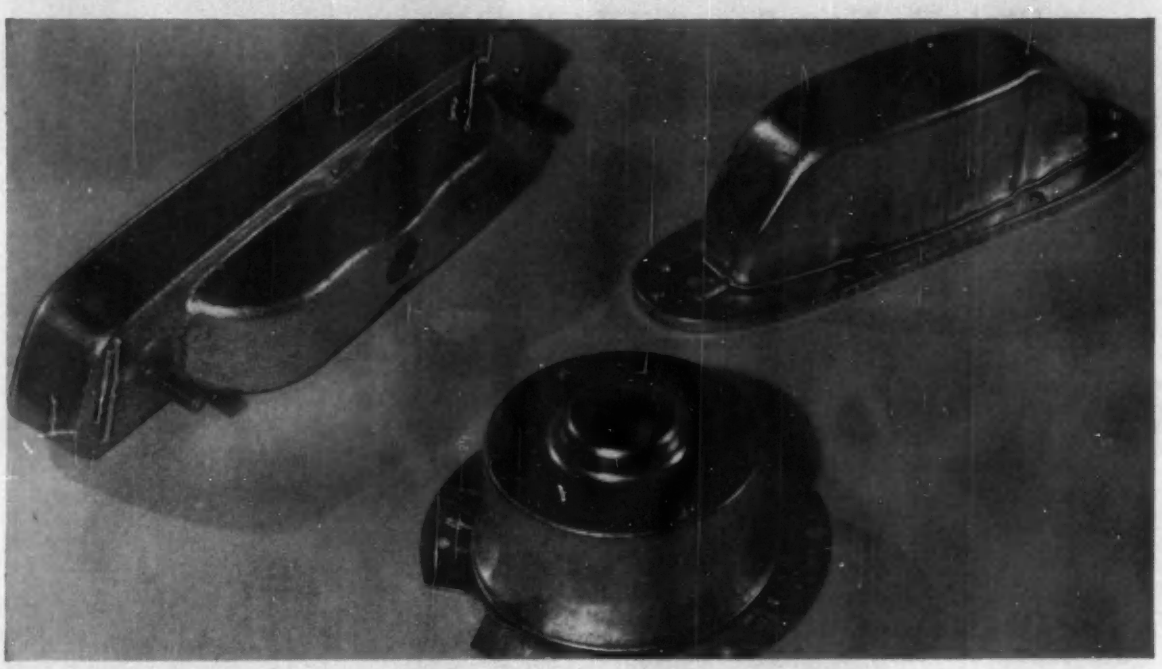
©1958, R-S Corp.

WORLD'S LARGEST MANUFACTURER OF AXLES FOR TRUCKS, BUSES AND TRAILERS

Products of **ROCKWELL-STANDARD** Corporation

even after severe working...

Auto parts stay Zinc-Protected with Armco ZINCGRIP Steel



zinc coating stays intact because it flows with the base metal

Rust can't find a foothold on these parking lamp housings for new model automobiles. There are no zinc-bare spots. And Armco ZINCGRIP® Steel is the reason why.

In spite of operations that draw, form, and pierce this durable steel, the hot-dip zinc coating continues to protect the base metal. It does not flake or peel.

Why not consider this workable, rust-resisting steel for parts *you* make that require severe fabrication and must fight corrosion? It's available in coils for use in high-speed production equipment.

To get the full story, just fill in and mail the coupon or call your nearest Armco Sales Office. There's no obligation.

Your Armco Sales Office can also supply complete data about other Armco Steels for top-quality automotive products. They include stainless steels, ALUMINIZED STEEL, ZINCGRIP PAINTGRIP®, High Strength Steel, Long Ternes, Steel Tubing, and high-quality Hot- and Cold-Rolled sheets.

New steels are born at Armco

ARMCO STEEL CORPORATION, 2888 Curtis St., Middletown, Ohio
Send complete information about Armco ZINCGRIP.

We make_____

NAME_____

TITLE_____

COMPANY_____

STREET_____

CITY_____ ZONE_____ STATE_____

ARMCO STEEL

Armco Division • Sheffield Division • The National Supply Company • Armco Drainage & Metal Products, Inc. • The Armco International Corporation • Union Wire Rope Corporation • Southwest Steel Products

Mining and Drilling Equipment, Crawler Crane and Hoist Manufacturers specify . . .

HEIM *Unibal*®
SPHERICAL BEARING
ROD ENDS

There are heavy duty Heim Unibal Rod End Bearings with BIG capacity and durability for use on unusually heavy linkages. They operate the compressed air clutch; they control the swing mechanism and the steering brakes; they help eliminate slack in the reverse swing and travel clutches; and contribute to the dependability and low maintenance of such heavy duty equipment.

The shapes and sizes, methods of fabrication and types of attachment to adjacent units are as varied as the number of installations. Heim Unibal is easy to install, easy to inspect, and easy to maintain.

No other device can correct misalignment better than Unibal, the spherical bearing. The maximum angle of misalignment for each of three types of mountings most commonly in use, is shown in this drawing . . .

For rod end applications in linkage mechanisms, other limiting factors may prevail, but the ability of the Unibal Rod End bearing to correct misalignment varies only in degree.

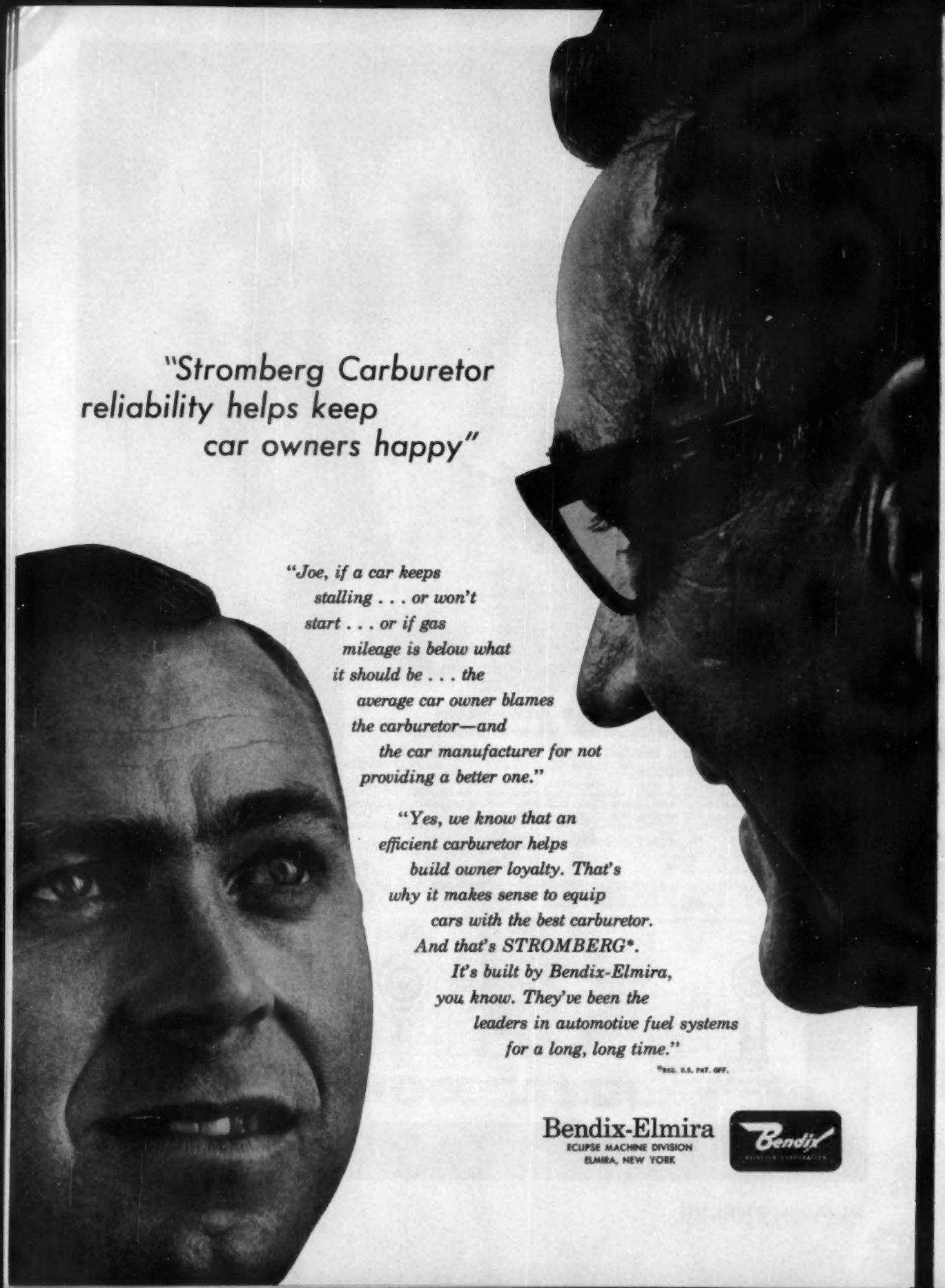
A wide range of stock sizes is available.

HEIM UNIBAL SPHERICAL BEARING ROD ENDS

Rod End	D	B	G	Maximum Static Radial Load
E Series	.1900 – .5000	.750 – 1.312	1.750 – 3.031	2,648 – 7,292 lbs.
GI Series	.1900 – .2500	.750 – .938	1.935 – 2.969	1,699 – 3,723 lbs.
HF Series	.1250 – .7500	.609 – 1.750	1.085 – 3.750	1,201 – 11,326 lbs.
HM Series	.1250 – .7500	.609 – 1.750	1.172 – 3.750	452 – 11,326 lbs.
HFX Series	.2500 – .7500	.750 – 1.750	1.687 – 3.750	5,398 – 23,234 lbs.
HMX Series	.2500 – .7500	.750 – 1.750	1.937 – 3.750	5,398 – 23,234 lbs.

Components for Unibal Rod Ends are made of various suitable materials. Lubricators are supplied when specified. The Heim catalog gives complete specifications on all stock items; be sure to have one at your finger tips.

THE HEIM COMPANY • FAIRFIELD, CONN.



"Stromberg Carburetor reliability helps keep car owners happy"

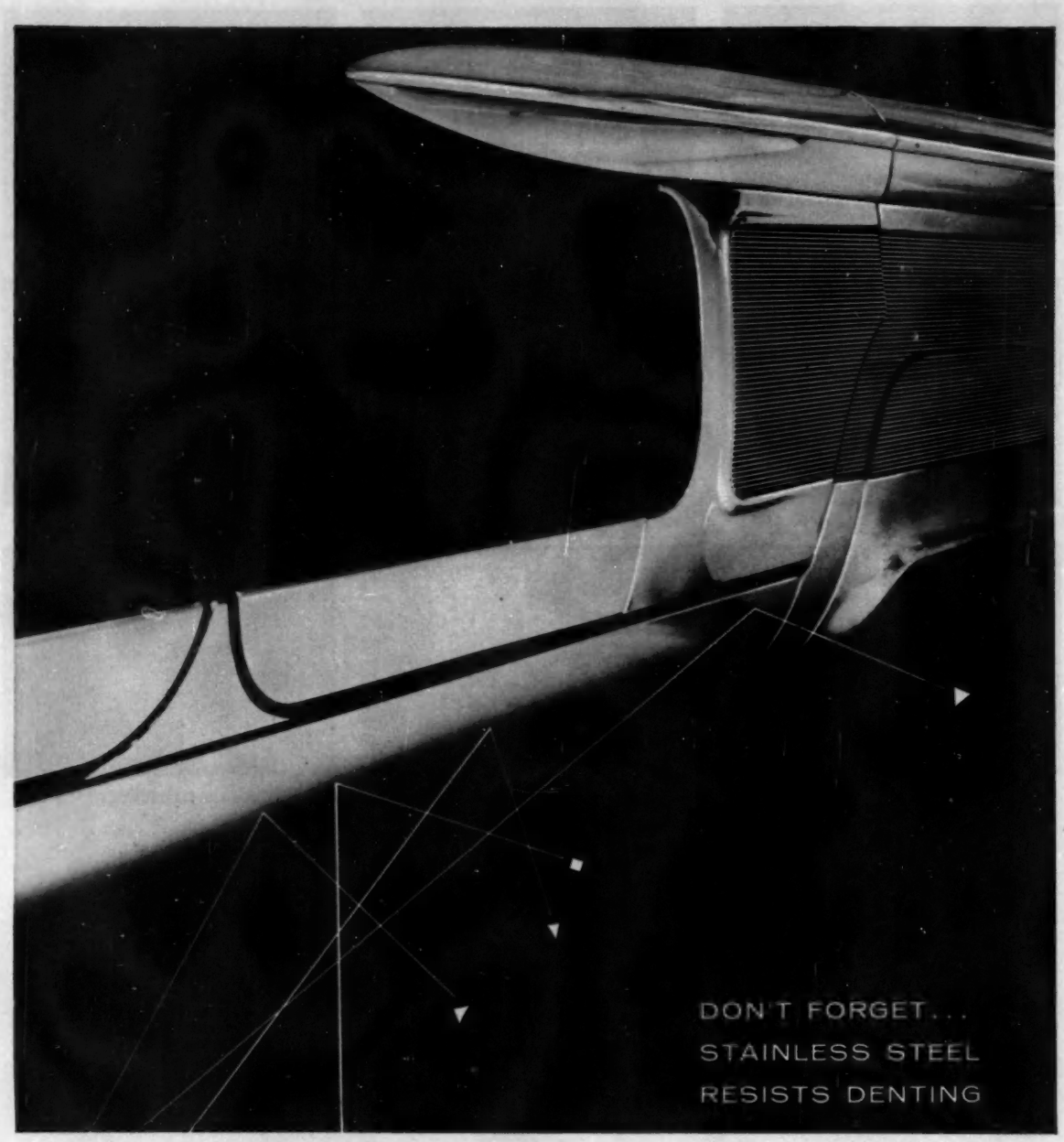
"Joe, if a car keeps stalling . . . or won't start . . . or if gas mileage is below what it should be . . . the average car owner blames the carburetor—and the car manufacturer for not providing a better one."

"Yes, we know that an efficient carburetor helps build owner loyalty. That's why it makes sense to equip cars with the best carburetor. And that's STROMBERG. It's built by Bendix-Elmira, you know. They've been the leaders in automotive fuel systems for a long, long time."*

*REG. U.S. PAT. OFF.

Bendix-Elmira
ECLIPSE MACHINE DIVISION
ELMIRA, NEW YORK

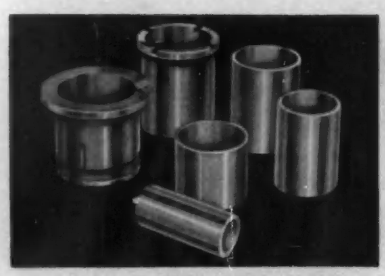
Bendix
AVIATION CORPORATION



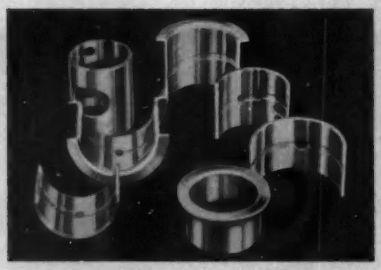
Elementary? Yes, but it's a vital reason why car buyers — a whopping 57 per cent of them — prefer stainless trim. They know stainless beauty is *lasting* beauty . . . it adds to *resale* value, too. Stainless steel resists scratches, road chemicals, corrosion, never peels, comes bright with soap-and-water washing. And the *best* stainless steels are made with Vancoram Ferro Alloys. Your supplier can give you more details about the added value you can build into your autos — with *stainless steel!* Vanadium Corporation of America, 420 Lexington Avenue, New York 17, New York.

Producers of alloys, metals and chemicals

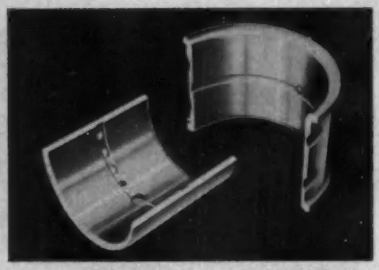
VANADIUM CORPORATION OF AMERICA



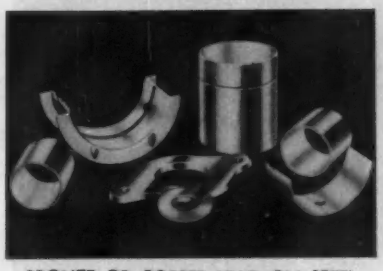
CAST BRONZE



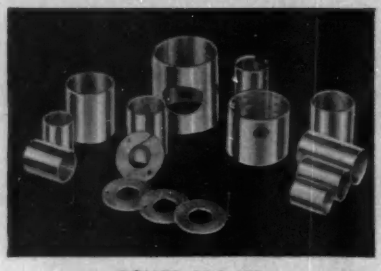
BABBITT AND STEEL



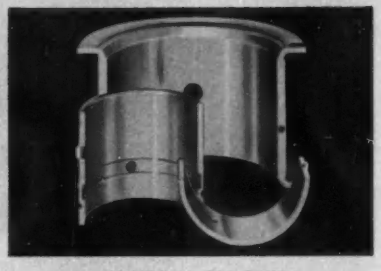
BABBITT AND BRONZE



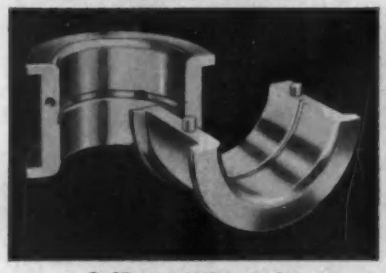
BRONZE OR COPPER-LEAD ON STEEL



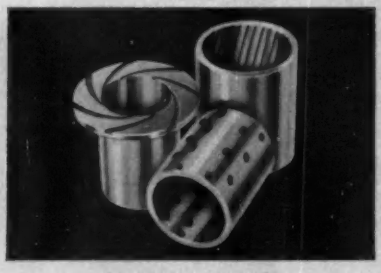
ROLLED BRONZE



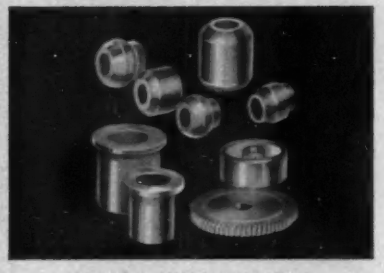
ALUMINUM ON STEEL



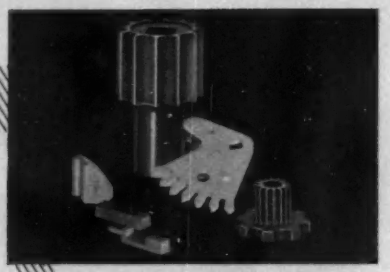
CAST ALUMINUM ALLOY



GRAPHITED BRONZE



LEDALOYL SELF-LUBRICATING



POWDERED IRON

When you need Sleeve Bearings Call on . . .

Johnson Bronze can provide the solution. We produce all types of sleeve bearings in a number of standard sizes. In addition, we have the facilities to produce an infinite variety of custom-made bearings to your specifications. The best bearing for any application can be found among the types illustrated above. To get the exact bearing you need at reasonable cost, contact Johnson Bronze Company, 675 S. Mill Street, New Castle, Pa.

Johnson Bronze

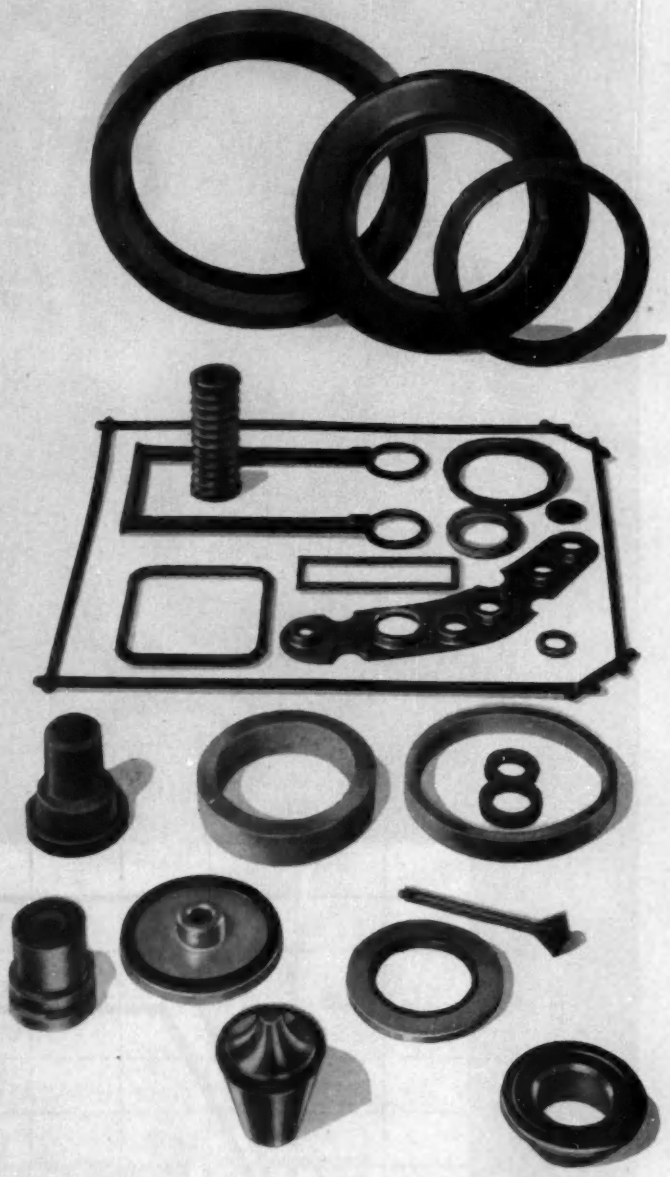
Subsidiary: Apex Bronze Foundry Co., Oakland, California

Rubber Parts engineered to your product by PRECISION

THE production of rubber seals, poppets and diaphragms of intricate shape and form – especially engineered to meet individual product requirements – is a Precision specialty. Parts are compression molded for uniform density ... have maximum resistance to compression set ... meet military-standards and specifications ... solve close tolerance problems.

If you're looking for the answer to a heat, compression, friction, or fluid resistance sealing problem, ask for the services of a recognized sealing specialist – the Precision engineer.

Precision "O" Rings, Rubber and Rubber Bonded-to-Metal Parts



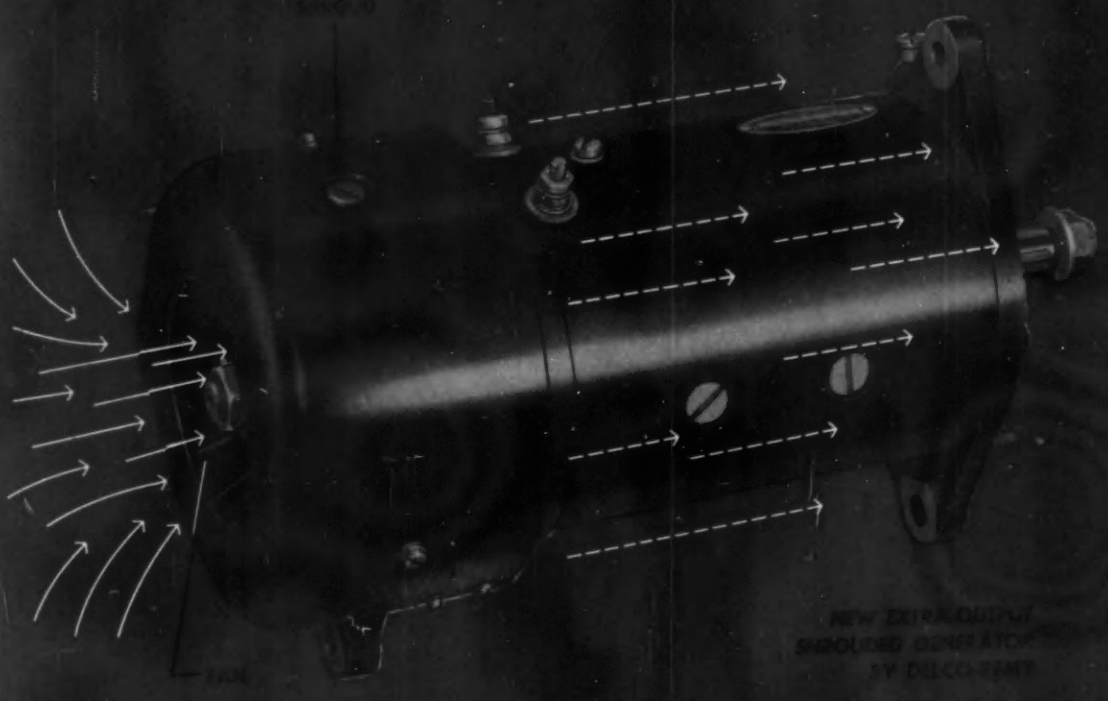
Precision Rubber Products Corporation

"O" Ring and Dyna-seal Specialists

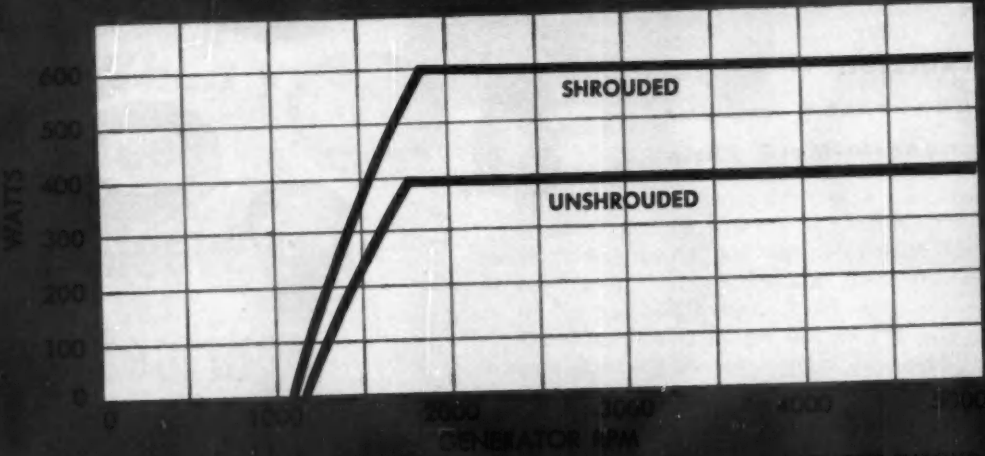
3110 Oakridge Drive, Dayton 7, Ohio

Canadian plant at: Ste. Thérèse de Blainville, Québec

PROGRESSIVE ENGINEERING MAKES THE DIFFERENCE



NEW EXTRA-QUIET SHROUDED GENERATOR BY DELCO-REMY



COMPARATIVE OUTPUTS OF ENCLOSED GENERATORS WITH AND WITHOUT SHROUD

NEW DELCO-REMY TOTALLY ENCLOSED GENERATORS OFFER 50% MORE OUTPUT WITHOUT INCREASE IN SIZE

Delco-Remy's new, totally enclosed shrouded generators offer up to *50% more* output than former enclosed models of this size. They are especially designed for construction vehicles and off-the-road equipment subject to extremes of dust and moisture, or corrosive materials. Because they are totally enclosed, they are *splash-proof* and *dust-proof*.

Key feature of the new units is a high-efficiency fan mounted at the commutator end in a compact, formed steel shroud. The shroud-controlled air blast travels closely along the generator frame where it produces rapid and effective cooling . . . makes possible up to *50% more output*, without the added cost of increased frame size.

For every kind of heavy-duty operation, Delco-Remy generators provide greater power and reliability with long life. Be sure to specify Delco-Remy shrouded generators—where required—for your new equipment. Readily available in 6-, 12-, and 24-volt models for replacement application on present equipment through the United Motors System.

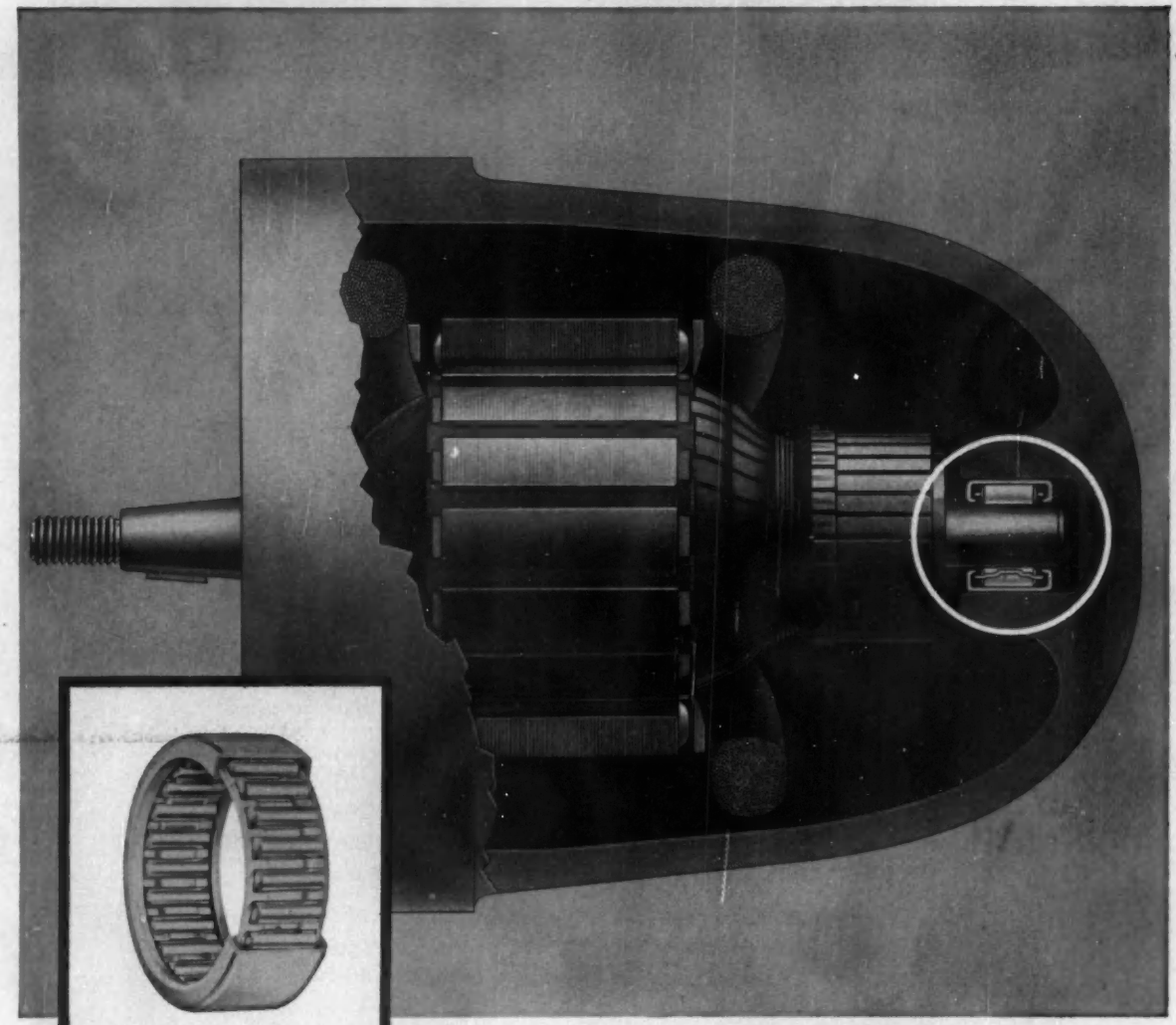
DELCO-REMY • DIVISION OF GENERAL MOTORS • ANDERSON, INDIANA

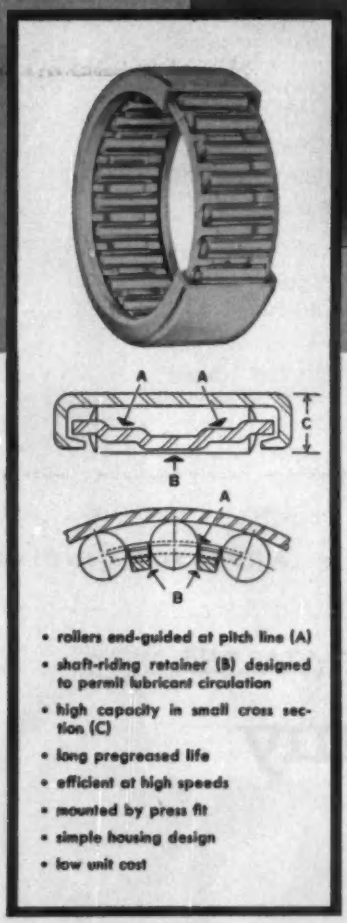
GM GENERAL MOTORS

GENERAL MOTORS LEADS THE WAY—STARTING WITH

Delco-Remy

ELECTRICAL SYSTEMS





- rollers end-guided at pitch line (A)
- shaft-riding retainer (B) designed to permit lubricant circulation
- high capacity in small cross section (C)
- long pregreased life
- efficient at high speeds
- mounted by press fit
- simple housing design
- low unit cost

Save up to 50%
on armature bearing costs!

Low unit cost of the new Torrington Drawn Cup Roller Bearing reduces armature bearing cost as much as 50%. This unique bearing gives excellent service at high speed and permits prelubrication for life.

Test installations and service applications show the bearing performs efficiently at speeds up to 25,000 rpm in intermittent service of 1000 hours and more. In such service, initial lubricant lasts the life of the motor. Most applications require no seals. This, with the simplicity of housing design, contributes further to economy.

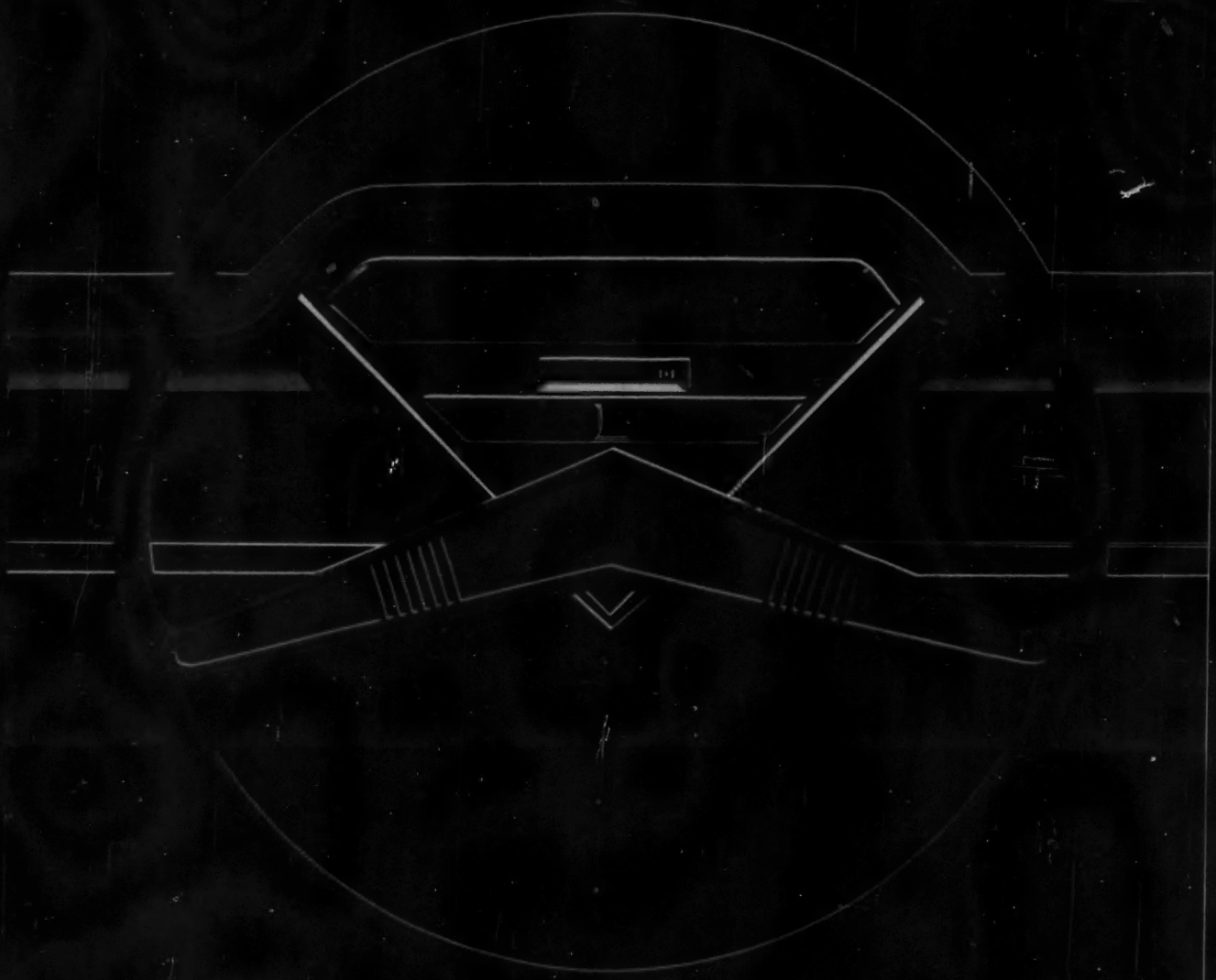
Designers are invited to evaluate the Torrington Drawn Cup Roller Bearing for such applications as generators, power tools, electric mixers, vacuum cleaners and other appliance motors where considerations of cost, speed, efficiency and light weight are paramount.

Services of Torrington's engineering staff are offered to assist you in design developments of every type of electric motor. **The Torrington Company, Torrington, Conn.—and South Bend 21, Ind.**

TORRINGTON BEARINGS

District Offices and Distributors in Principal Cities of United States and Canada

NEEDLE • SPHERICAL ROLLER • TAPERED ROLLER • CYLINDRICAL ROLLER • BALL • NEEDLE ROLLERS • THRUST



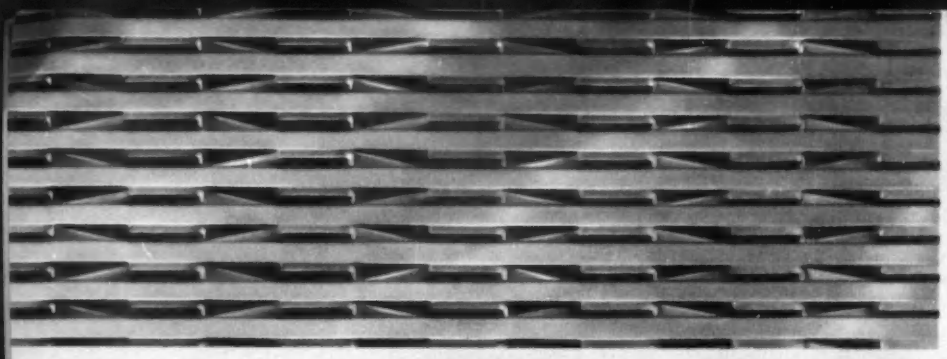
Aluminum Interior Trim

adds colorful, lasting, sales-appealing beauty in fine new cars

The Finest Products Made with Aluminum

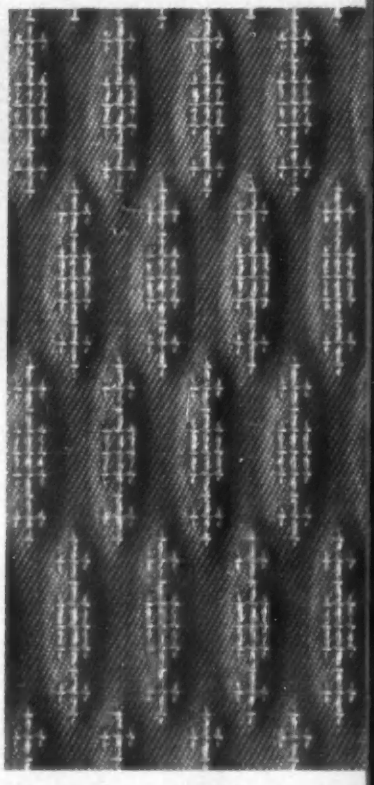
are made with REYNOLDS ALUMINUM

TURN PAGE FOR INTERIOR TRIM INFORMATION.....



Aluminum door panel trim, scuff plates

New Aluminum textures and finishes offer important sales and manufacturing advantages



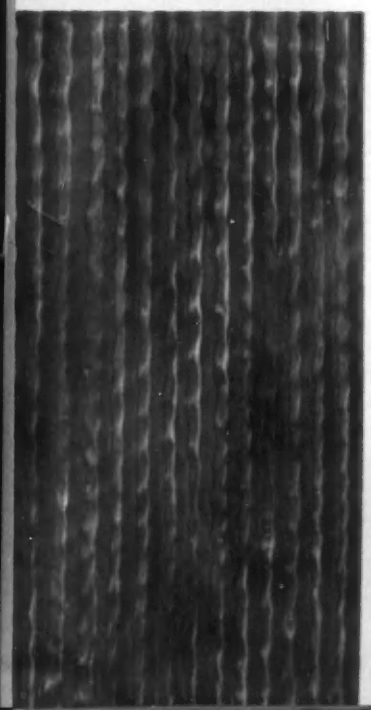
Aluminum seat skirts, seat back trim

Reynolds Aluminum "gleam of gold" and "look of sterling" are currently adding lasting, sales-appealing beauty in both interior and exterior applications. Now—for still broader interior use in instrument panels, seat skirts and many trim parts—a variety of attractive new textures and finishes are intriguing automobile manufacturers. In addition to clear and color anodized combinations, contrasting colors can also be added through the use of organic finishes.

These aluminum parts will not rust, chip, pit, peel or flake. They create customer appeal . . . assure lasting beauty . . . increase design freedom . . . offer a "new look" at modest cost . . . permit manufacturing economies.

On trim applications and on countless other decorative or functional applications, Reynolds Aluminum Specialists will be glad to work with you to help you get the very most from the aluminum you use. For details on this service and on aluminum mill products or fabricated aluminum parts and trim, call your nearest Reynolds Office. Or write *Reynolds Metals Company, Fisher Building, Detroit 2, Michigan or P.O. Box 2346-MU, Richmond 18, Virginia.*

NOTE: Before you buy any part—have it designed and priced in aluminum. Basic material costs do not determine part costs. New techniques and processes—applicable only to aluminum—can give you a better product at a lower *final* cost.



REYMET—Reynolds Aluminum Yarn—lends sparkling beauty to automobile upholstery

The Finest Products Made with Aluminum are made with REYNOLDS ALUMINUM

Reynolds Aluminum

the metal for *automation*

TRADE MARK

An invitation to senior scientists and engineers

A $14,000,000 R & D Center, housing 9 new laboratories, was revealed as core of Republic's $35,000,000 Research and Development Program at recent announcement by Mundy I. Peale, President, and Alexander Kartveli, Vice-President for Research and Development.

.... To join Republic Aviation's new $35 million Research and Development Program for spacecraft, missiles and advanced aircraft

In announcing Republic's $35 million research and development program, designed to arrive at major breakthroughs in the aviation industry's transition to astronautics, Mundy I. Peale, President, set the following objectives:

"...ACCELERATION OF PROJECTS ALREADY UNDER WAY AT REPUBLIC ON LUNAR PROGRAM FOR MANNED SPACE VEHICLES, AND MISSILES TO DESTROY ORBITING WEAPONS, AND INITIATION OF INVESTIGATIONS LEADING TO NEW CONCEPTS FOR INTERPLANETARY TRAVEL."

"...RADICAL NEW FAMILIES OF LONG-RANGE AIR-TO-AIR MISSILES AND AIR-TO-SURFACE BALLISTIC MISSILES FOR STRATEGIC AND TACTICAL AIRCRAFT."

"...VERTICAL TAKE-OFF FIGHTER-BOMBERS, HIGH-MACH FIGHTER-BOMBERS, AND SUPERSONIC TRANSPORTS."

Alexander Kartveli, Vice-President for Research and Development, emphasized that Republic's program "will not duplicate in any way investigatory work currently in progress elsewhere, but will stress novel concepts and new approaches to basic problems of missiles and space technology."

The program includes construction of a $14 million R & D center to house 9 new laboratories, and anticipates doubling the present research staff.

Senior men interested in the new possibilities created by a simultaneous exploration of all aspects of Flight Technology are invited to study the functions of the new laboratories for more detailed information:

SPACE ENVIRONMENTAL DEVELOPMENT LABORATORY
To simulate space flight conditions and test missile, satellite and spacecraft systems and components; investigate human engineering problems.

RE-ENTRY SIMULATION & AERODYNAMIC LABORATORY
To study hypersonic shock dynamics, real gas effects, heat transfer phenomena and magnetohydrodynamics.

MATERIALS DEVELOPMENT LABORATORY
Study effects of high velocity, temperature, and space environment on materials for spacecraft, missiles and advanced weapons.

GUIDANCE & CONTROL SYSTEM DEVELOPMENT LABORATORY
To develop and test guidance and control systems for spacecraft, missiles and aircraft.

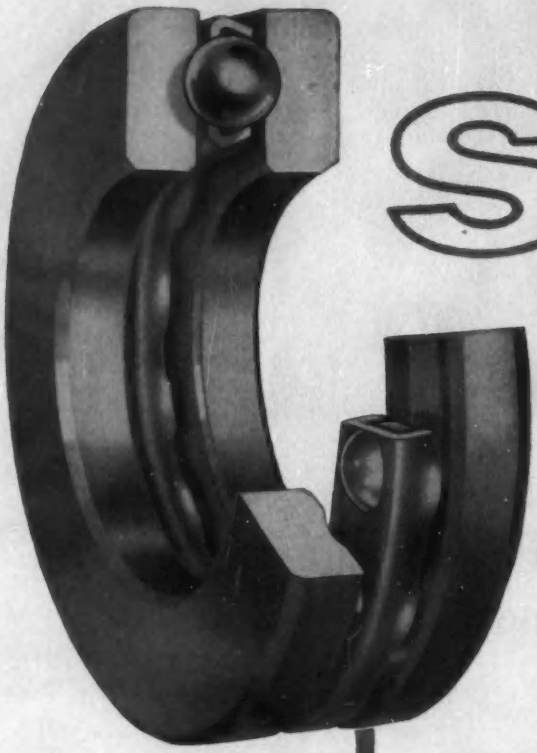
ELECTRONICS DEVELOPMENT LABORATORY
Study and explore all problems connected with highly specialized, complex electronic systems required for advanced forms of spacecraft, missiles and aircraft.

ADVANCED FLUID SYSTEMS DEVELOPMENT LABORATORY
To develop and test fluid power systems for spacecraft and missiles capable of operation under extremely high temperature, high pressure conditions.

MANUFACTURING RESEARCH & DEVELOPMENT LABORATORIES
To develop advanced manufacturing processes and techniques for materials used in missiles and spacecraft. Laboratories for each of the following areas: *Non-Metallics, Metallics, Welding.*

Qualified men are invited to write directly to:
A. Kartveli, Vice President, Research and Development

REPUBLIC AVIATION
FARMINGDALE, LONG ISLAND, NEW YORK



SAVE with Aetna BEARINGS

SAVE design adjustments and compromises

The Aetna line of quality precision bearings is so complete and diversified that within it there is undoubtedly the exact bearing, with the exact specifications, required for your design. No need to modify or change your design—no need to specify characteristics which require extra-cost handling.

This is especially true of Thrust Bearings—a field in which Aetna is the acknowledged leader—with a broad line of sizes and load ratings to meet practically all requirements from stock.

SAVE assembly costs

Precision dimensions held to exact tolerances guarantee press fit without effort or adjustment. Bearings received in perfect, factory-fresh condition, require no cleaning—no checking or inspection. Simply remove from carton, strip off the protective wrapper and install.

SAVE repair and replacement losses

Aetna bearings stand up under the loads and service for which they are designed—give long hours of perfect anti-friction performance—require no attention beyond periodic lubrication—seal out dirt, dust, grit and atmospheric impurities—and permit your equipment to deliver the fine, trouble-free performance which you have built into it.

DO YOU HAVE THE NEW AETNA GENERAL CATALOG AND ENGINEERING MANUAL?

Contains valuable engineering data, formulas, tables, design application drawings, shaft and housing fits, lubrication helps, etc. in a compact, readily accessible unit.

Secure your copy by phoning your local representative listed in your Classified Phone Book or write direct.

AETNA BALL AND ROLLER BEARING COMPANY

DIVISION OF PARKERSBURGH-AETNA CORPORATION • 4600 SCHUBERT AVE. • CHICAGO 39, ILL.

In Detroit — Sam T. Keller — 1212 Fisher Bldg.

Aetna ANTI-FRICTION CONSULTANT TO LEADING ORIGINAL EQUIPMENT MANUFACTURERS SINCE 1910

POWER BOOSTING RICHFIELD'S 2-CYCLE GAS COMPRESSORS

Richfield Oil Corporation's compressor installation at Coles Levee, California, is one of several which have accumulated thousands of hours of trouble free operation with the Multiple AiResearch Turbocharger System.

...*The Multiple* **AIRESEARCH** *Turbocharger System*

has helped solve the Richfield Oil Corporation's need for more power to meet increased demands at its compressor stations. Turbocharging the 2-cycle natural gas engines with the Multiple AiResearch Turbocharger System proved to be an economical and quick method for boosting power.

The turbocharger installation is simple and clean. Two production-type AiResearch turbochargers are mounted directly on the exhaust manifold. The compressed air is directed to the engine intake through an AiResearch intercooler. This increases engine output from 300 H.P. to 375 H.P.

AiResearch is a leader in the development and production of air-cooled turbochargers and turbocharger controls for all major diesel engine applications.

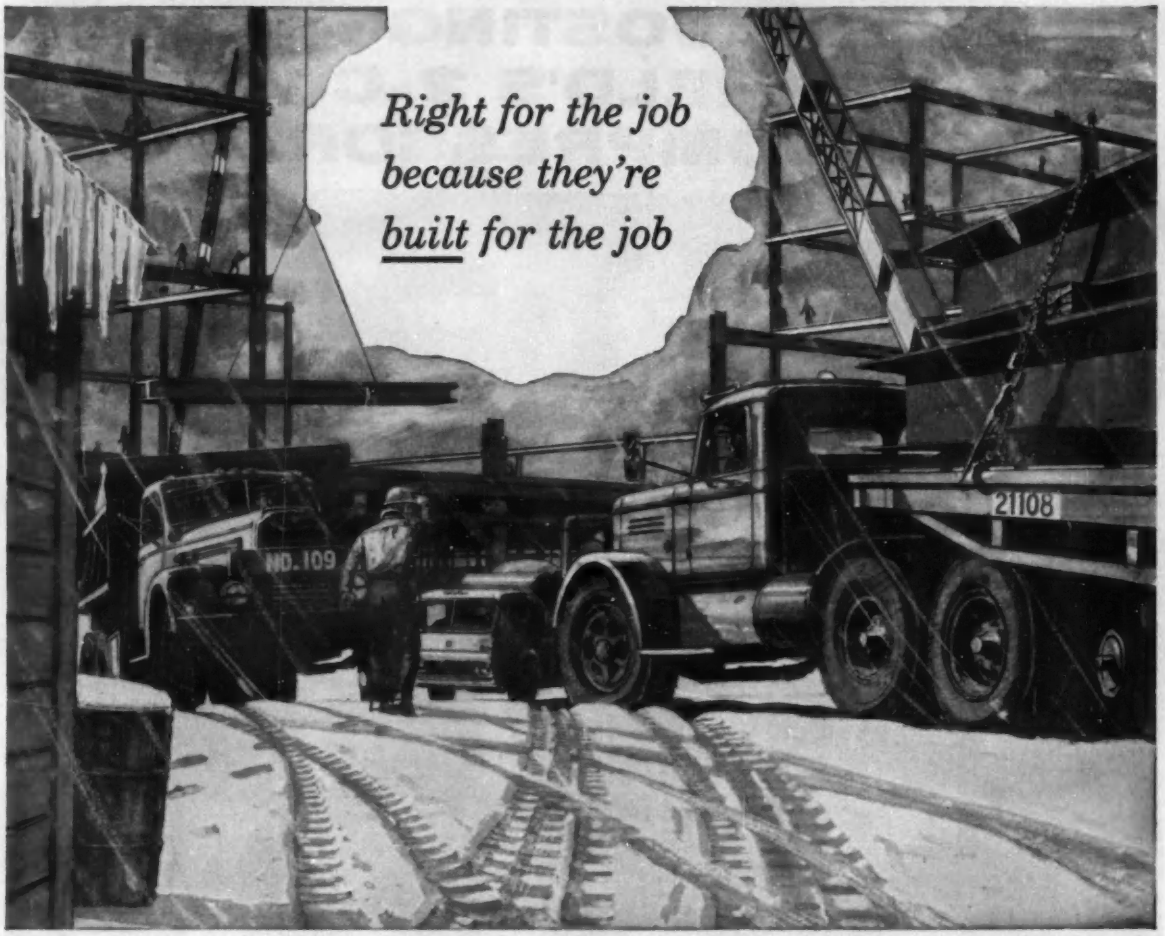
Your inquiries are invited.

THE GARRETT CORPORATION

AiResearch Industrial Division

9225 South Aviation Blvd., Los Angeles 45, California

DESIGNERS AND MANUFACTURERS OF TURBOCHARGERS AND SPECIALIZED INDUSTRIAL PRODUCTS



EVANS HEATERS ARE RIGHT FOR TRUCKS BECAUSE THEY'RE BUILT FOR TRUCKS

It goes without saying that your truck has to be *truck built* all the way through. Including the heater!

You'll find *every* Evans heater is *truck built*. Each is designed to meet the specific heat and installation requirements of the type truck it is to serve. This means both correct BTU output *and* proper heat distribution ... something a warmed-over car heater cannot provide.

It also means longer heater life. To prove it, Evans backs every heater with a parts "repair or replace" warranty good for a full year or 50,000 miles, whichever occurs first.

An Evans heating engineer will be happy to work with you in solving *your* truck heating problems. Write for complete information: Evans Products Company, Dept. Z10, Plymouth, Michigan.

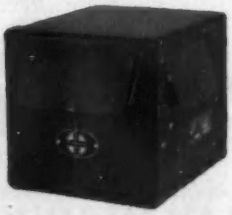
Regional Representatives: Cleveland, Frank A. Chase
Chicago, R. A. Lennox Co., Inc.; Detroit, Chas. F. Murray Sales Co.
Allentown, Pa., P. R. Weidner

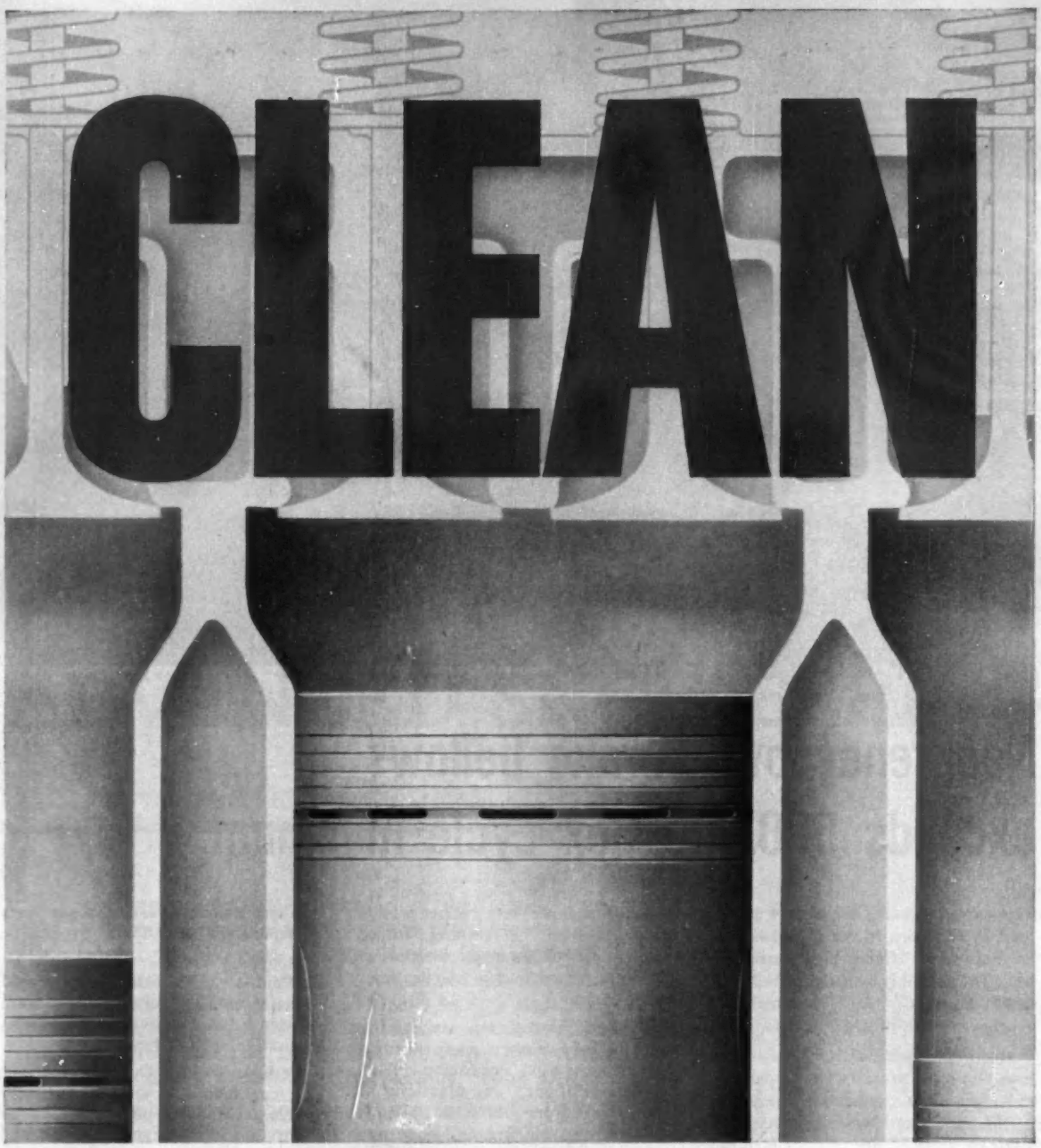
EVANS PRODUCTS COMPANY ALSO PRODUCES:

railroad loading equipment; bicycles and velocipedes; Evaneer® fir plywood; fir lumber; Evanite® battery separators; Evanite® hardboard; Haskelite doors; Evanite Plywall.

EVANS PRODUCTS COMPANY

PLYMOUTH, MICHIGAN





PARANOX-BLENDED OILS HELP KEEP ENGINES CLEAN!

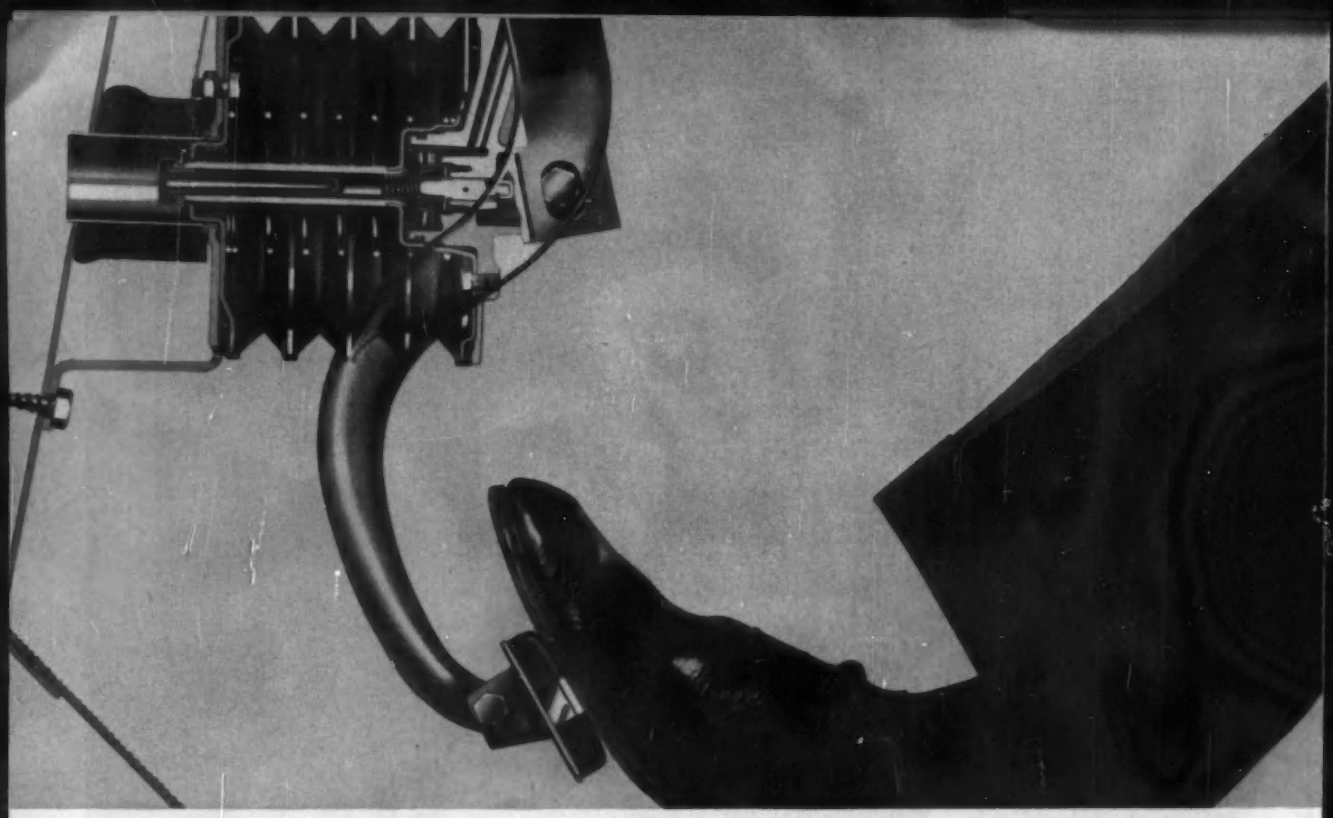
Ordinary lubricating oils take a beating in big, hard-working heavy-duty engines. High temperature, open-throttle operation causes hard varnish formations and oxidation breakdown. Low-temperature, short-period use causes wet sludge and deposits. Oils blended with *Paranox*® stay *clean* and *lubricate* at *all* temperatures for better performance and longer periods between overhauls.

Enjay has developed the *only complete line* of high quality additives (Paramins®). To meet the most exacting lubrication specifications, insist on Enjay Paramins.

ENJAY

Pioneer in Petrochemicals

ENJAY COMPANY, INC., 15 West 51st St., New York 19, N. Y. • Akron • Boston • Charlotte • Chicago • Detroit • Los Angeles • New Orleans • Tulsa



Neoprene power brake bellows exceeds 500,000 flex cycle minimum

This power brake unit is now being used by the Ford Motor Company on its Ford and Thunderbird passenger cars. The assembly is made for Ford by Kelsey-Hayes Company, and includes a bellows made of Du Pont neoprene.

Neoprene was the choice for this bellows because it proved its dependability to Kelsey-Hayes engineers in a series of preliminary tests. Most important was a test of its resistance to flex cracking.

Kelsey-Hayes specified a minimum flex life for this bellows of 500,000 cycles. A trial neoprene bellows passed without a trace of cracking. (Since then, sample bellows made of neoprene have been flexed over a million times without failure.)

Kelsey-Hayes engineers say that the neoprene bellows meets many other requirements as well. For example, it retains its resiliency and elasticity at temperatures from −40°F. to 200°F. It is resistant to oil, grease, ozone and abrasion. Another important advantage is neoprene's low degree of permanent set. This means that the bellows will keep its airtight seal for many years of dependable operation.

Neoprene synthetic rubber, made by Du Pont for 26 years, is also being used in many other automotive applications. Heater hose, fan belts, air springs, vacuum tubing . . . these are just a few.

Perhaps there's a Du Pont elastomer that can help you solve a particular problem. Mail the coupon below for more information on properties and uses of neoprene—as well as HYPALON and VITON, two other Du Pont automotive rubbers.

ELASTOMERS IN ACTION HYPALON® · NEOPRENE VITON TRADEMARK

DU PONT
REG. U. S. PAT. OFF.

Better Things for Better Living
. . . through Chemistry

☐ I am particularly interested in _____

☐ Add my name to the free mailing list for *Du Pont Elastomer News for Automotive Engineers* (reviews new automotive applications of neoprene, HYPALON and VITON).

☐ Add my name to the free mailing list for the *Elastomers Notebook* (contains articles based on uses of Du Pont elastomers in industry).

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Elastomer Chemicals Dept. SAE-10
Wilmington 98, Delaware

Name _____
Firm _____
Address _____
City _____ State _____

Guarding the quality of your castings...

SAND, METALLOGRAPHIC LABORATORIES
CHEMICAL AND PHYSICAL RESEARCH
MILLION VOLT X-RAY INSPECTION
TEST FOUNDRY FACILITIES
SPECTROGRAPHIC ANALYSIS
ADVANCED ENGINEERING

and safeguarding costs...

Keeping quality in castings uniformly "up" is an exacting science—takes highly specialized equipment and a vast know-how from engineering, metallurgical and other technical staffs. Yet costs at CWC are as low as totally mechanized foundry facilities can make them. Here, you get both—top quality, low cost—in castings that machine easier, wear longer.

Write for our booklet, "One Source"—tells all about CWC's outstanding facilities for supplying you with the finest castings available.

50 YEARS OF PROGRESS
in better foundry methods
... in wider use of castings

Campbell, Wyant and Cannon
FOUNDRY COMPANY
DIVISION OF TEXTRON INC.
MUSKEGON, MICHIGAN

SIX FOUNDRIES LOCATED IN MUSKEGON, LANSING AND SOUTH HAVEN, MICHIGAN ... READY TO SERVE YOU!

CWC
founded in 1908

New Holley '59 Carburetors can be serviced in minutes— WHILE ON THE ENGINE!

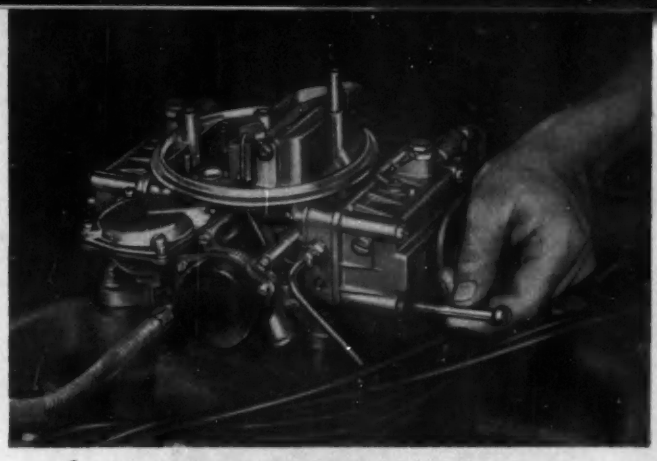
Many 1959 automobiles and trucks will be equipped with newly designed Holley two and four barrel carburetors that have a special needle and seat assembly which makes carburetor service a matter of minutes.

All carburetor minor repair—90% of carburetor service requirements under 30,000 miles—can be completed in the time it takes to remove and replace a single spark plug; and, without removing the carburetor from the engine.

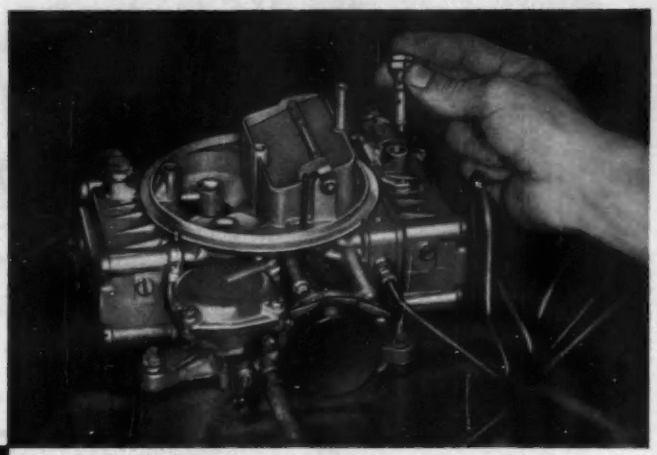
These Holley 1959 models will substantially reduce customer service complaints and will make minor repair work more profitable and more accurate for the service man. With just the four simple steps shown on this page service men can:

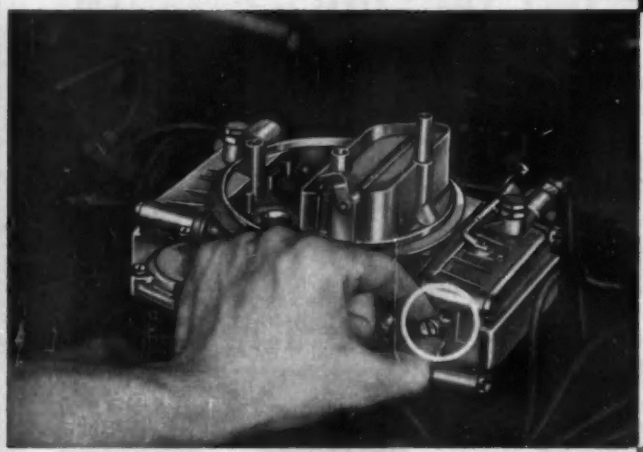
1. Purge the carburetor of dirt and foreign matter.
2. Accurately adjust the fuel level in the bowl.
3. Replace or adjust the fuel inlet needle and seat.

These new 1959 carburetors are another example of Holley's continuing leadership in the design and engineering of fuel and ignition equipment.



1 *With ignition off, remove lower bowl screw farthest from fuel inlet. Allow all gasoline to drain, purging the carburetor of dirt and sludge.*

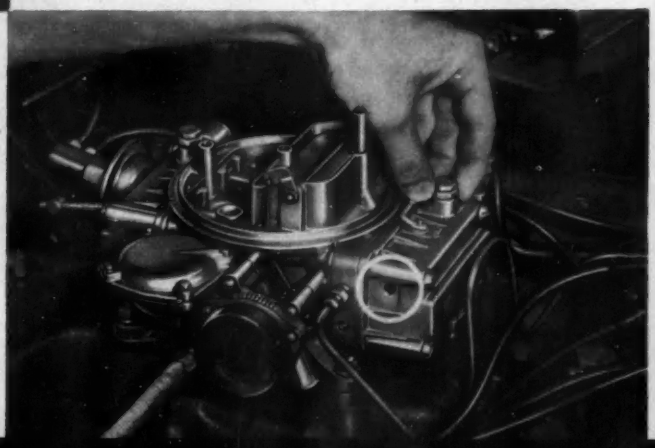




2 *Remove fuel needle and seat and examine for wear and general condition. Replacement can be made at low cost although there should be no evidence of wear until after 20,000 miles.*

3 *With engine running, remove sight plug from carburetor bowl opposite fuel inlet. If fuel level is too high, excessive fuel will drain through sight plug opening. For proper operation, fuel level should be on line with threads at bottom of sight port.*

4 *Loosen top lock nut on needle and seat assembly and adjust with lower nut until float maintains fuel at desired level. Tighten lock nut and minor repair is completed.*



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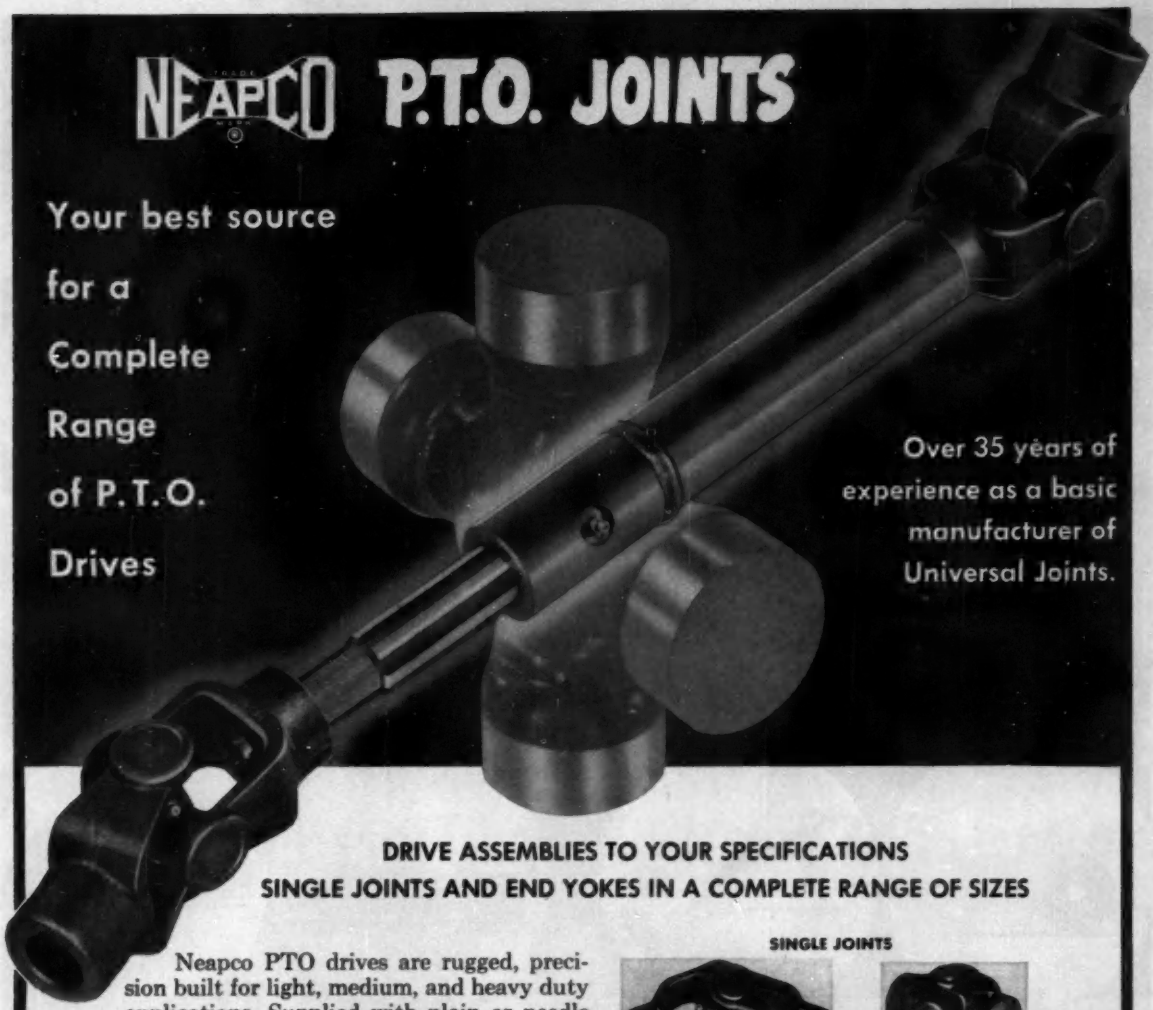

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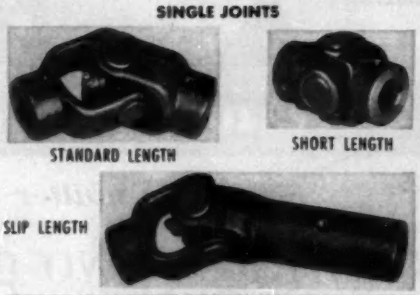
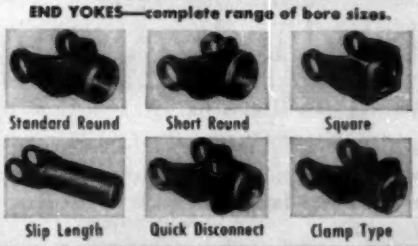
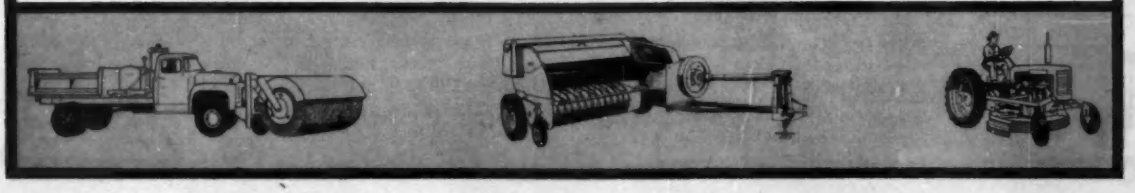
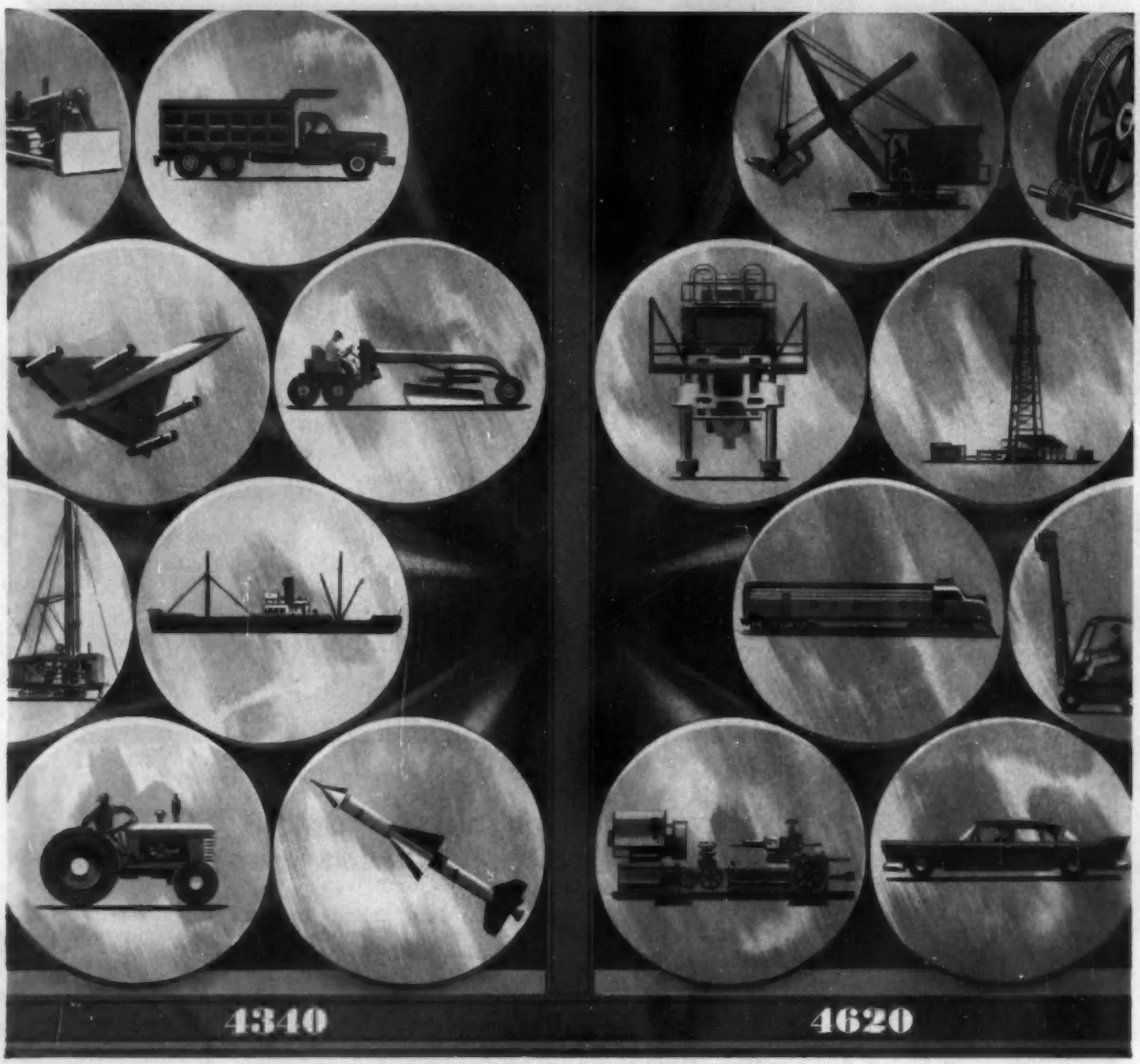


END YOKES—complete range of bore sizes.







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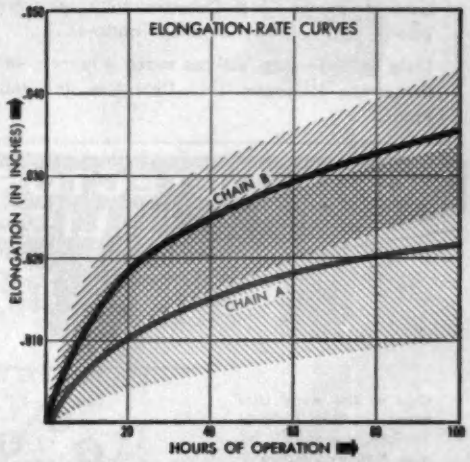

Morse 53-121 Timing Chain (A) showed 24% less elongation than other chain (B), after 100 hours at 4000 rpm under a 90-lb. load on the Hydraulic Impulse Machine—a very severe test that has been correlated with road and dynamometer test runs.

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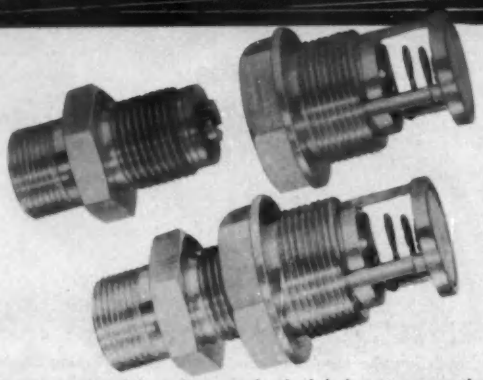

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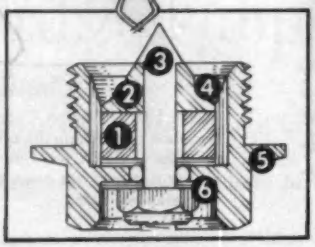

One of the many Lisle Magnetic Chip Detector Designs, showing (1) Alnico Magnet (2) Magnet Extension (3) Non-Magnetic Terminal Shaft (4) Insulating Tube (5) Plug Body (6) O Ring.

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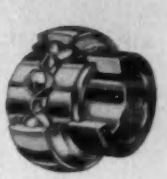

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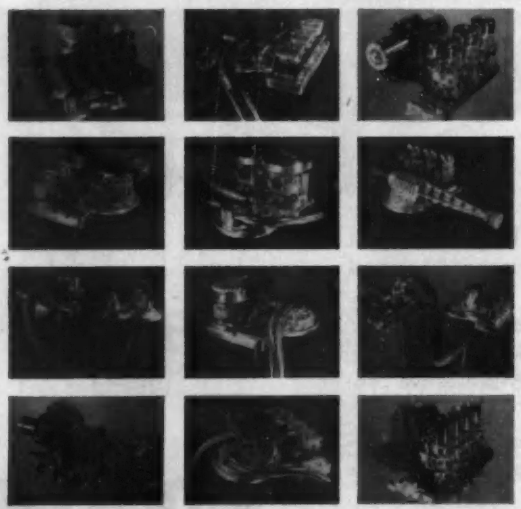

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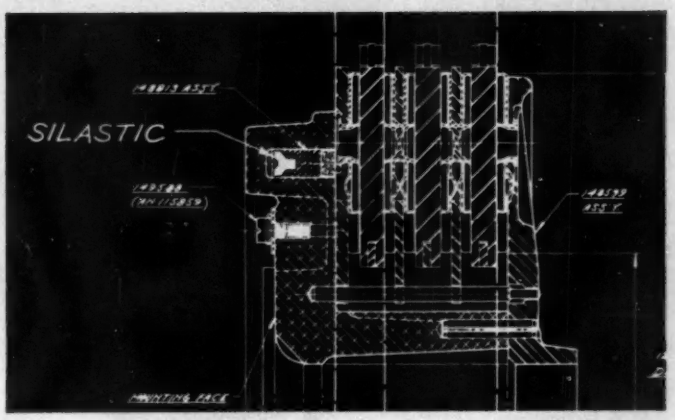

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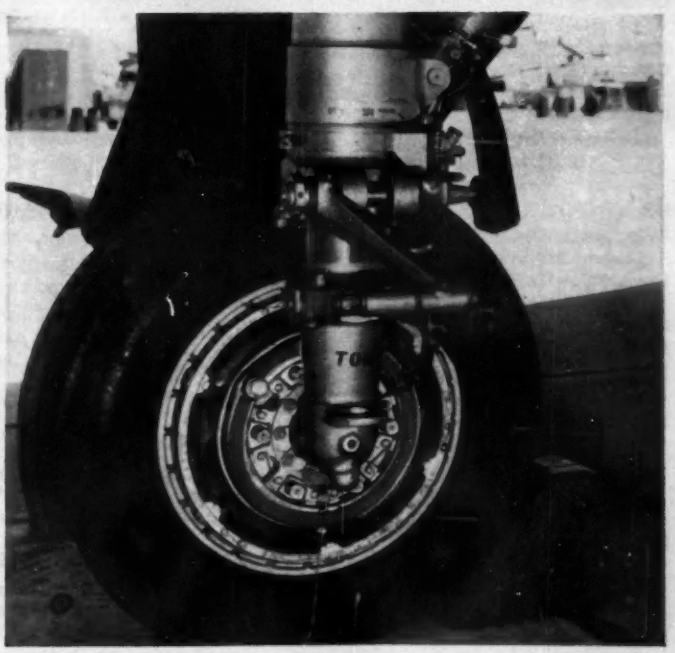

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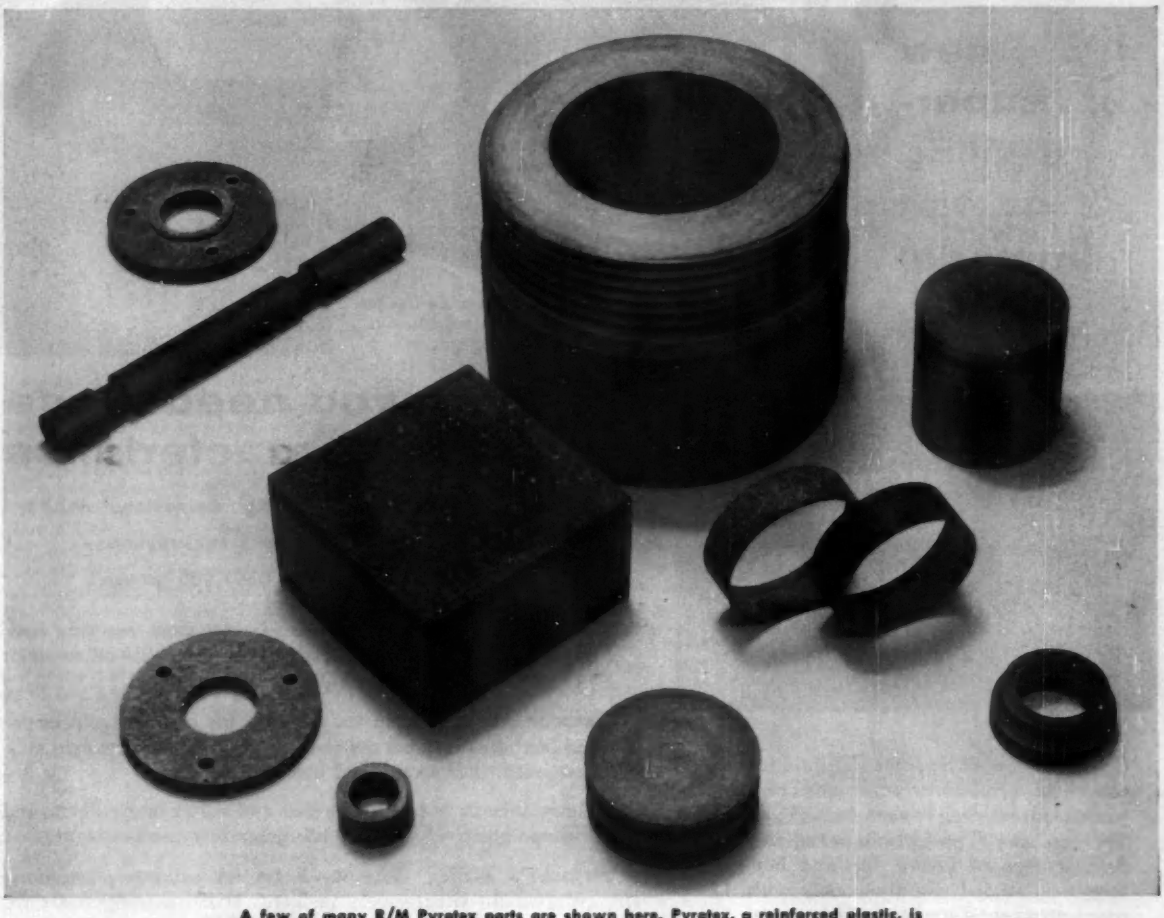

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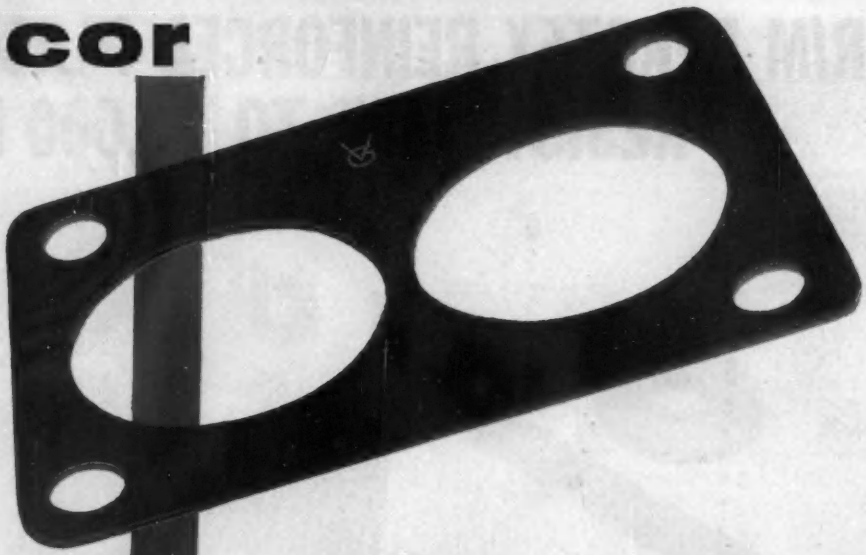
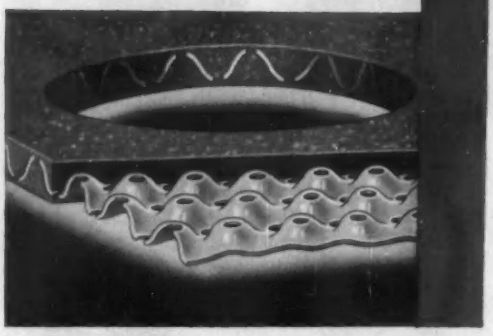
Victocor

new super-sealing gasket material





Cross section of **Victocor**. Thin steel core is die-formed with continuous projections alternating in each face. (Type 200 core has 800 projections per sq. in.) Sealing element layers, top and bottom, are bonded simultaneously with core into integral structure. Deep penetration of core projections increases stability and heat conductivity.

TYPICAL PHYSICAL PROPERTIES — TYPE 200

Thickness	.030/.035" min.
% Compressibility at 1000 psi.	*10-15
% Recovery at 1000 psi.	35 min.
% Compressibility at 5000 psi.	*16-21
% Recovery at 5000 psi.	30 min.
Service temperature	750 deg. F.
Crush resistance psi.	100,000
Corrosion resistance against aluminum, magnesium, steel and copper	Good

*Slightly higher values are obtained with heavier gauge.

. . . where you need these maximum characteristics

- low torque loss
- high heat resistance
- high crush resistance
- high dimensional stability
- thin construction— .030/.035 gauge

Victocor justifies re-examination of your most exacting sealing specifications. It's a totally new product—offers more in every desirable heavy-duty characteristic.

Victocor was developed particularly for high-flange-pressure applications. Its steel core construction accelerates heat conductivity. It is strong and highly flexible.

Resistance to hot oils, gasoline and water is excellent, and **Victocor** positively retains all commonly used coolants.

Victocor's sealing element—a special asbestos-elastomeric compound—is extremely resilient. It helps compensate for mating surface irregularities. No coating is required when installing **Victocor** gaskets, and they're easily removed for replacement.

4 Standard Types Available—Test Samples Free

Where can you seal better and more economically with **Victocor?** Let Victor engineers help you decide. It's available in four standard types and many modified combinations. Meanwhile, write for complete technical data and free test samples. Please mention proposed application. Address the factory, or contact your Victor field engineer.

Victor Mfg. & Gasket Co., P.O. Box 1333, Chicago 90, Ill.
Canadian Plant: St. Thomas, Ont.

VICTOR

Sealing Products *Exclusively*

GASKETS • PACKINGS • OIL SEALS • MECHANICAL SEALS

THIS IS GLASS

a bulletin of practical new ideas from Corning

It's cooler inside!

Sitting behind the controls of this crane in a steel mill used to be a hot job. But now cab windows are made of ¼" polished plate that's fashioned from PYREX brand *infrared reflecting* glass.

This glass *bounces* heat away—transmission of IRR (infrared) being as low as 7%, depending on wave length. Yet you can see through these windows since about 75% of visible light is passed. These IRR windows are strong, chemically resistant, and very durable. You can get them in sizes up to 30" x 60". For details (along with data on blue observation glass, PYREX brand glass No. 7740, and VYCOR brand glass No. 7900) ask for PE-34, a 4-page data sheet covering flat glass properties, specifications, and applications.

Hot rod

This has *nothing* whatsoever to do with motor cars. Rather our concern here is a piece of *glass* rod that conducts electricity and produces heat.

The rod is ¼" O.D., made of heat-resistant glass coated with a metallic oxide that's fired in for permanence. Ends are silvered so you can use clip contacts.

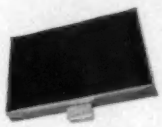
NEW, low-watt density heater from Corning consists of glass rod, coated with a metallic conductor, and having silvered ends for attaching clip contacts.

With either a 120 or 240 volt source, you have a power *output* rate of roughly 50 watts for every 6 inches of rod.

Someone described this low-watt density heater as "a non-crystalline, rigid wire made of glass." The big question: What can you do with it? So far the project development people at Corning have come up with hot rods ranging in size from 6 to 24 inches. Larger sizes are being looked into.

Seems like a compact heater like this should be good for lots of things. We await your suggestions and inquiries.

Working on the same principle of a metallic coating that conducts electricity to produce heat are panels like this.



These panels are called PYREX brand industrial radiant heaters. You'll find them in use in plants 'round the country for drying, heating, baking, curing.

Main reason for the popularity of these heaters is the kind of heat you get. It's *uniform*, and *long wave*—5 microns and over.

And long wave heat is very readily *absorbed*. For example, here's comparable performance for a white surface.

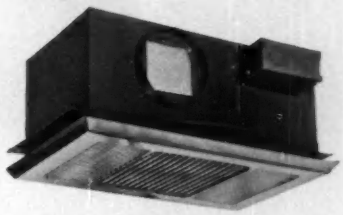
Source	Temperature °K	% radiant energy absorbed
infrared lamp	2500	30
sheathed wire unit	1000	70
"PYREX" heater	600	90

With the long wave heat from PYREX® heaters, color is of *little* importance—heating speed is almost constant.

PYREX industrial radiant heating panels are mounted in an aluminized steel frame and come complete with built-in reflector, mounting hangers, junction box, and leads.

All the facts about this efficient way to get heat are spelled out in Bulletin PE-60. Use the coupon if you'd like a copy.

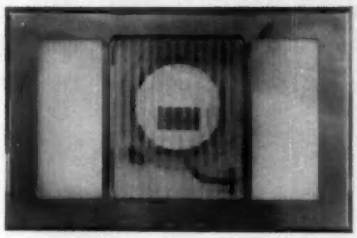
Inside job



This combination ventilator and lighting fixture is compact and smart looking. It's made by Fasco Industries, Inc., a Rochester, N. Y., firm.

Mounted in the ceiling, this fixture exhausts stale air and provides illumination for bath and/or utility rooms.

Where do we enter the picture? The grille is made of 7½"-long pieces of *glass* rod. Glass makes for smooth air flow, looks good, and stays that way.



And the 4"x7" lighting panels are Corning No. 66 Alba-lite—an opal glass in an attractive fluted pattern. Alba-lite diffuses; it stands up to the heat from the 60-watt lamps. It, too, looks good, and is easy to keep clean.

Suggestion: If anything you make (or contemplate making) uses glass parts, try Corning. You'll get *what* you want, *when* you want it, in the *quantities* you need, at a *price* that makes sense.

Or as a starter, ask for "This Is Glass." In its 64 pages you'll probably find something you can use. Remember: *Corning can do almost anything with glass.*

Corning means research in Glass

CORNING GLASS WORKS, 40-10 Crystal Street, Corning, New York

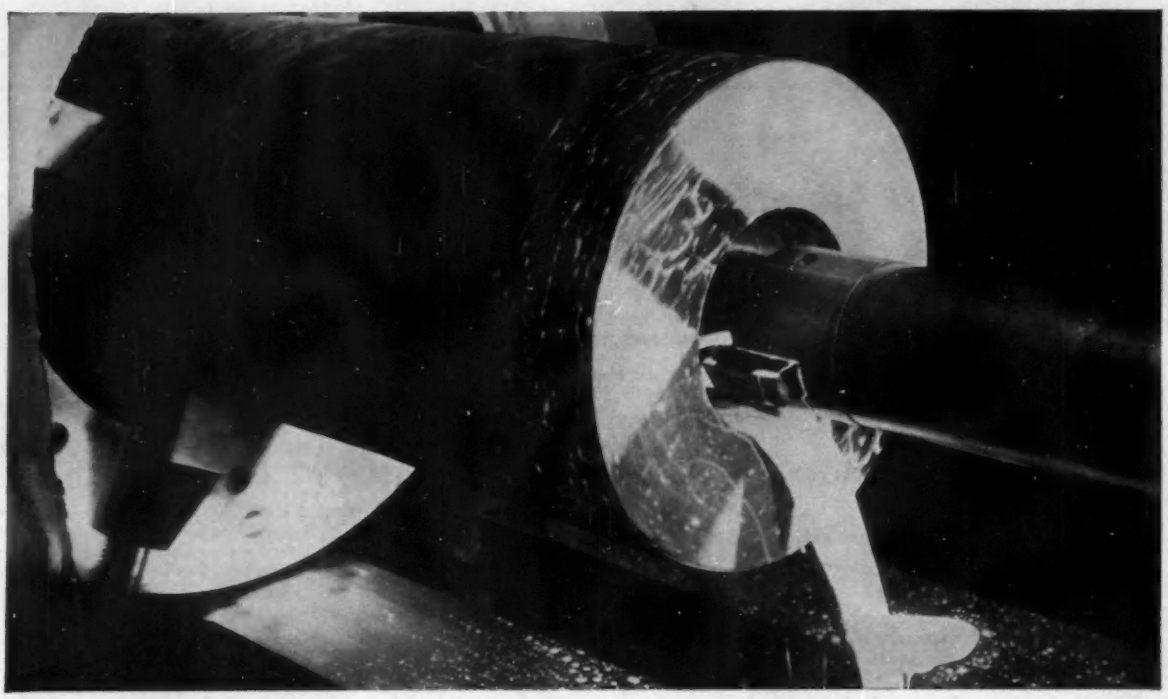
Please send me: ☐ PE-34 "Corning Flat Glasses"; ☐ PE-60 "PYREX brand industrial radiant heater catalog"; ☐ "This Is Glass"

Name.....Title.....

Company.....

Street.....

City.....Zone.....State.....



Finish boring is your first step with Timken® seamless steel tubing —the hole's already there!

YOU save time and money when you make hollow parts with Timken® seamless steel tubing instead of bar stock. You eliminate drilling because the hole's already there. Finish boring is your first production step. With less metal to machine away you get more parts per ton of steel.

And because Timken seamless steel tubing eliminates one boring operation, your screw machine stations are free for other jobs. You get more machining capacity without adding machines.

And you get a better quality finished product with Timken seamless steel tubing because of the way we make it. A solid round is forged over a mandrel, thoroughly working the metal inside and out. This rotary piercing operation gives Timken seamless steel tubing its fine forged quality, uniform spiral grain flow. With exacting control of temperature and piercing speed, we maintain this quality from tube to tube, heat to heat, order to order.

And to further increase your steel savings, Timken Company engineers will be glad to recommend the most economical tube size for your hollow parts job. You'll get a size guaranteed to clean up to your dimensions. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable: "TIMROSCO".

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